TECHNICAL GUIDELINES

1. 02440 -- Irrigation Systems

A. Scope of Work

These standards and procedures apply to the design and installation of a complete underground irrigation system for landscaped areas, lawns, and planting beds. The system shall include the construction site and adjacent areas as defined in the project program.

B. General Requirements

1. All trenches must be deep enough to allow eighteen (18) inches cover for lateral lines, twenty-four (24) inches cover for sprinkler main and quick coupling line, and twenty-four (24) inches minimum on main water line to backflow prevention device.

2. Pipe shall lay side by side in trench and shall be separated by two (2) inches of clean fill. No stacking of pipe in trench.

3. All sprinkler systems will have a quick coupler backup system. Quick coupler line shall have full line pressure and not pass through sprinkler PRV (Rainbird 33K) every 100'.

4. Generally, piping under existing concrete or asphalt shall be installed by jacking, boring or hydraulic driving. Where any cutting or breaking of sidewalks, concrete work and/or asphalt is necessary, it shall be removed and replaced by the contractor. Permission to cut or break sidewalks, concrete and/or asphalt shall be obtained from the Project Manager. All pipe and control wires shall be installed inside sleeves under all pavements. Sleeve shall be 1-1/2 the diameter of the pipe that passes through it. No bunching of pipes in sleeve, no fitting on pipe inside of sleeves under eighteen (18) foot long. Plug upper end of sleeve that is installed on a slope with duct tape for backflow protection of the system.

5. Site standard is Febco 805Y. All backflow devices shall be as approved by the Department of Health under regulations set forth in WAC 248-54-480 and WAC 248-54-500.

6. All mains on upstream side of backflow prevention device shall be Type L copper pipe. All pipe inside or under building shall be Type "L" Copper.

7. The system shall be designed for water velocities not to exceed five (5) feet per second.

8. Automatic System

   a. Permanent sprinkler installations shall generally be designed for full-automatic operation. System design shall take into account time, length and frequencies of sprinkling as well as the local nature of the soil and plantings; and shall be zoned accordingly. Rainbird Maxicom to be connected in all applications.

   b. A manual shutoff valve shall be installed to isolate the system from the supply main. Use copper pipe & fittings.

   c. All sprinkler systems shall be designed for complete drainage by air pressure.

d. Piping connections to sprinkler heads with one-inch inlet and shall include double swing joints or approved.

e. Sprinkler heads shall be staggered in location. Laterals shall be laid across prevailing slopes as nearly level as possible. Static pressures within any one system shall not vary more than 10 percent. Lateral sprinkler lines shall be sized for pressure drops not in excess of 20 percent of the average sprinkler operating pressure.

9. Quick Coupler System

a. Quick coupler systems shall consist of Rainbird 33 DRC quick coupling valves set at maximum spacing of 100'. Installation shall be such that hoses will not cross walkways and roads.

b. Quick couplers shall be installed on 3/4' galvanized triple-swing joints, with galvanized riser.

c. All quick couplers are to be installed in turf boxes with the top of the quick coupler no more than 1.5' from bottom of turf box lid.

d. Owner to be provided with three Rainbird 33 DK quick coupling keys.

10. Plastic Pipe and Joints

a. All plastic to plastic joints shall be solvent-weld joints. Only the solvent recommended by the pipe manufacturer shall be used. All plastic pipe and fittings shall be installed as per manufacturer's recommendations and field assistance. All solvent will be kept in original can with expiration date legible.

b. All plastic to metal joints on electric valves shall be male SC Sch. 40 H40 PUL adapters. All connections from plastic to metal on DCVA to be made with Brass Fond Fittings

c. The joints shall be allowed to set at least 24 hours before pressure is applied to the system on PVC pipe.

11. Valves

a. Gate Valves - All zone shutoff valves or other valves not indicated as manual angle control valves, sizes two (2) inches and smaller shall be all bronze model, disc sedge type with integral taper seats and with rising stem. All gate valves 2-1/2 inches or larger and not indicated as manual angle control valves shall be iron body, brass trimmed, double disc sedge type with integral taper seats and with non-rising stems. Gate valves shall be Hammond, with brass cross handles.

b. Automatic Valves - Automatic control valves shall be Rainbird GB Series (Brass) only.

c. Automatic valves shall be assembled with a Schedule 40 PVC male adapter on the upstream side, and a Schedule 40 PVC male adapter followed with a PVC union or PVC Slip-fix on the downstream side.

All threads to be Teflon taped only. No “pipe dope” is permitted.

Automatic valves shall rest on minimum six inches of pea gravel inside the valve box.

12. Backflow Prevention

a. Internally Loaded Double Check Valve Assembly - Shall be used where quick coupler, hose bibs, electrical or manual valves are installed upstream or when sprinkler main comes from the basement of a building. Use FEBCO 805Y only. See Standards Drawing SD-C-14 for vault installation.

There shall be manual shutoff valve on each side of the double check valve.

The test cocks shall face away from the wall. The double check valve shall be installed in an accessible area to facilitate maintenance and testing. The double check valve must be protected from freezing.

b. Do not use PVB’s.

13. Automatic Controllers

a. All systems shall be integrated with a single computerized central control unit (Rainbird Maxicom) installed to manufacturer's requirements. Solenoid master valves and flow sensors shall be installed on the mainline downstream of double check valves. Field/Satellite controllers shall be located to facilitate service to this system.

b. All wall mounted controllers shall be mounted with bottom of the controller case a minimum of four (4) feet from the floor or ground level and with top of controller a maximum of six (6) feet from the floor or grounded level.

c. All controllers to be Rainbird ESP-MC Series only.

d. All local and applicable codes shall take precedence in the furnishing and/or connecting of the 110 volt electrical service to the controller. All controllers shall be UL approved and have a resettable circuit breaker to protect valves and transformers against damage due to shorted circuits.

e. Provide metal conduit protection for the 24 volt service wires leading from the controllers and extend at least 24 inches below ground level or six (6) inches below floor level.

f. The controller shall be wired so the zones are in chronological order starting with the zone next to the controller.

14. Control Wire

a. Tape wires together at ten (10) foot intervals and lay under to supply line. A minimum three (3) foot coil of wire shall be provided at each valve box.

b. No splices of lead wire between valve and controller. Separate lead or "hot" wire to each automatic valve. Common ground wire is acceptable. All splices shall be in valve boxes. Splice with Dri-Splice wire connector or equal. Extra control wire to be run to the remote valves of the system but not connected (for future repairs).

c. Minimum size of wire as follows:

Number of Valves	Maximum Length of Common Wire			
	500	1000	2000	3000
1	14	14	14	12
2	14	14	12	10
3	14	14	10	8

d. Color Code as follows:

Extra Control Wire Orange
Ground Wire White
Lead-in Wire Red

15. Sprinkler Heads

a. Rainbird 1800 Series sprinkler heads to be installed with spiral barb fittings and 1/2" polyethylene swing pipe.

b. Falsons and R-50 sprinkler heads to be installed with Schedule 80 PVC triple swing joints. All threads to be Teflon taped. No "pipe dope" permitted.

16. Valve Boxes

a. All remote control valves, manual control valves, zone shutoff valves, gate and double center valves shall be installed in suitable access box of proper size as required for easy access to the valve. Concrete box with steel lid shall be used in concrete or asphalt areas. Plastic box and lid shall be used in lawn or shrub areas.

b. All valve access boxes shall be installed on a suitable base of gravel for proper foundation of box and easy leveling of box to proper grade and also to provide proper drainage of the access box. A minimum of 2 cubic feet of wash gravel on valve box under two (2) inch valve size and 3 cubic feet on two (2) inches or larger valve size.

c. All valve access boxes shall be provided with proper length and size extensions, wherever required, to bring the valve boxes level with the finish grade.

C. Products

1. No substitutions will be permitted which have not been submitted for prior approval by City's authorized representative. All materials shall be new without flaws or defects and

shall be the best of their class and kind. Sufficient descriptive literature and/or samples must be furnished for any materials submitted as "equal" substitutes. All materials shall be guaranteed for a period of one (1) year against material defects and workmanship.

2. Quick coupling valves: Rainbird 33 DRG.

3. Electric Valve: Rainbird GB Model.

4. Electric Controller: Rainbird ESP-MC Series only.

5. Double Check Valve: Febco 805.

6. Sprinkler Head:

   a. Lawn: Rainbird Falcon 45' and farther; Rainbird R-50 15'-45'; Rainbird 1804 8'-15',.

   b. Shrub: Rainbird 1806

7. Steel Pipe and Fittings:

   a. Steel pipe shall be new, scale free, mild steel pipe and shall be standard weight schedule 40 Galvanized pipe.

   b. Steel pipe fittings shall be used only as a riser for quick coupler assembly.

8. PVC Pipe and Fittings:

   a. PVC pipe shall be virgin, high impact polyvinyl chloride pipe, Type I only conforming to commercial standards CS 207-60, CS 256-63. Type II is not acceptable. Main to be schedule 40 and laterals shall be schedule 40 PVC pipe and fittings with solvent weld type joints except where risers, valves, etc., require threaded joints. Pipe shall be continuously and permanently marked with the following information: Manufacturer's name, kind of pipe, size, NSF approval and Schedule Number. All pipe shall be installed with fittings of the same schedule and manufacturer.

D. Execution

1. Pipe shall be laid in straight lines, without bends and curves.

2. Trenches for sprinkler lines shall be excavated of sufficient depth and width to permit proper handling and installation of the pipe and fittings. Backfill shall be thoroughly compacted and evened off with the adjacent soil level. Selected fill dirt or sand shall be used if soil conditions are rocky. In rocky areas the trenching depth shall be two (2) inches below normal trench depth to allow for this bedding. The fill dirt or sand shall be used in filling four (4) inches above the pipe. The remainder of the backfill shall contain no lumps or rocks larger than three (3) inches. The top six (6) inches of backfill shall be free of rocks over one (1) inch, subsoil or trash.

3. Testing:

a. Flush out system with all control valves opened with a full head of water.

b. Main lines to control valves to be hydraulic test at 160 pounds for 15 minutes, lines from control valves to sprinkler head to be tested at 100 pounds for 15 minutes before backfilling and in the presence of the A/E and a City Plumber. The line shall be acceptable with pressure drop of no more than 6 psi in 15 minutes on main and 5 psi on line from control valve to sprinkler head.

4. Record Drawings:

a. The contractor shall record all changes that have been made during actual installation of the system. Immediately upon installation of any piping, valves, wiring, sprinkler heads, etc., in locations other than shown on the original drawings, or of sizes other than indicated, the contractor shall clearly indicate such changes on a record set of drawings to be provided to the owner. The Contractor shall also provide the owner with a computer disk (CADD) which shows the as-built condition of the irrigation system.

b. The contractor shall provide a zone control map encased in plastic and mounted next to the controllers. The map will show main and zone valves and the locations they cover.

c. Before final acceptance the contractor will set a date for a walk-through and operation orientation.

d. After final acceptance of the completed installation, the contractor shall be responsible for having complete drawings prepared showing all such changes and these shall be turned over to the City Project Management for recording purposes per Section Part I, General.

2. 02660 -- Water Distribution

A. Scope

These standards and procedures apply to the design and installation of water service and distribution mains, owned and maintained by the City.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the following codes, regulations and standards:

1. The Uniform Plumbing Code with City of Seattle Amendments

2. The International Association of Plumbing and Mechanical Officials (IAPMO) Standards

3. American Water Works Association (AWWA) Standards

4. City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction.

General Requirements

1. Service mains will, in general be routed along pre-established utility corridors. The Project Manager will furnish the general line routings and sizes, as well as the location of connection points to the existing system.

B. Specific Requirements

1. Service mains shall be sized to meet the larger demands of either the maximum hourly domestic or the combination of maximum day domestic plus fire flow.

2. Fire flows shall be determined according to City of Seattle Fire Department requirements.

3. Yearly average domestic demands shall be the product of a 60 gallon per capita day usage and projected population densities. Maximum day rates shall be taken at 150 percent of this yearly average and the maximum hourly rate shall be set at 250 percent. System losses and unaccounted for usages shall be taken at 25 percent of the domestic demand.

4. Line velocities shall, in general, average 5 feet per second up to a maximum of 10 feet per second.

5. Mains shall be buried 36 inches below finished grade; no more or no less, unless approved by the Project Manager.

6. Gate valves eight (8) inch size and larger shall be fitted with an auxiliary bypass line and valve; four (4) inch size.

7. Gate valves eight (8) inch size and larger shall be installed in a standard valve chamber per Standards Drawing SD-C-6.

8. Maximum hydrant spacing shall be 300 feet and no hydrant shall be located closer than 40 feet to any building wall, subject to City of Seattle Fire Department review and approval.

9. Pipe bedding shall be installed in accordance with Section 7-10.3(9) of the Seattle Standard Specifications.

C. Products

1. Distribution main shall be Ductile iron AWWA C-151-76 Class 52 and shall be cement mortar lined per AWWA C-104.

2. Fittings shall be cast iron, AWWA C110 and C111 or AWWA C153 and cement mortar lined.

3. Jointing shall be in accordance with Section 9-30.1(1) of the Seattle Standard Specifications.

4. Valves shall be flanged, iron body, bronze mounted double disc gate; over eight (8) inches, valves to have non-rising stems. Maximum operating pressure shall be not less than 175 psi for valves up to twelve (12) inch size.

5. Valves shall be installed vertically in level lines and shall meet AWWA C500 specifications. Flanges shall be faced and drilled, ASA Class 235, for use with full face gaskets.

6. Fire hydrants shall conform to AWWA C502, shall be manufactured and pattern approved by the City of Seattle and shall be UL/FM approved. Hydrants shall have two (2) 2-1/2 inch and one (1) 4 inch connections, 6 inch riser barrel, 5 inch bottom valve and 6 inch connection to the main and shall be suitable for a working pressure of 150 psi. Hydrants shall be flanged and installed complete with auxiliary valve and box. See Standards Drawing SD-C-7.

7. Post Indicator valve shall be Kenny #641 or equal.

D. Execution

1. All water mains will be installed per Sections 7.09 through 7.15 of the Seattle Standard Specifications, except that connections to existing water mains owned and maintained by the City can be made by the Contractor or other designated City representative.

2. Connections to existing water mains shall not be made without first making necessary arrangements with the City Plumbing Department in advance.

3. Install new gate valve or connect to existing line - per requirements of City of Seattle Standard Plan 300.1.

4. Install new fire hydrants per requirement of City of Seattle Standard Plans 310.1a or 310.1b.

5. At the entry to buildings and at other locations where a water main crosses backfill, provide a concrete grade beam to support the pipe. Support off the building and/or firm soil.

6. Provide flexibility in piping on unstable earth and provide a flex joint at building entry.

7. Testing

   a. Shall be conducted in accordance with Section 7-11.3 (1) of the Seattle Standard Specifications.

(1) All lines and fire hydrants shall be subject to hydrostatic pressure testing after laying and blocking and prior to joint backfilling.

(2) Test pressure shall not be less than 50 psi above static, but no less than 200 psi or more than 200% of the working pressure for the class and size of pipe tested.

(3) The line shall be filled between valves with all air expelled at high points. Test pressure shall then be applied and maintained, for at least 2 hours. Test pressure must be maintained without pumping for 15 minutes with a pressure drop of less than 15 psi.

(4) A representative from the Executive Services Department Plumbing Shop shall witness and approve tests.

b. The Contractor shall make all necessary test arrangements and notify the following as to date and time of hydrostatic and bacteriological testing.

(1) Project Manager

(2) Consultant

(3) Environmental Health & Safety Department

(4) Seattle Fire Department

3. 02685 -- Gas Service

A. Scope

These standards and procedures apply to the design and installation of gas service lines.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the following codes, regulations and standards of latest issue:

1. The Uniform Plumbing Code
2. IAMPO Standards
3. APWA Specifications
4. Puget Sound Energy

Specific Requirements

1. Gas service lines will, in general, be routed along pre-established utility corridors. The Project Manager or Consultant Architect/Engineer will furnish the general line routings and sizes as well as the location of connection points to the existing system.
2. Gas piping shall be buried 30 inches below finished grade; no more or no less.
4. All pipe bedding shall be Type IV.

C. Products

1. Pipe shall be Black steel, schedule 40, welded or seamless, API-5L.
2. Fittings shall be Black steel, schedule 40, seamless, ASTM A234.
3. Valves shall be lubricated plug type, semi-steel, 175 pounds WOG.
4. Shop protective wrapping shall consist of coal tar enamel, AWWA C203-62 as modified in appendix Section A1.4.
5. Field protective wrapping shall consist of coal tar tape, glass reinforced, hot application.

D. Execution

1. Connections to existing and activation of all new lines will be under the supervision of the Puget Sound Energy.
2. Welders must have certification from either ASME, Section 9, or WABO certification.
3. Testing

a. In addition to inspection requirements of the Uniform Plumbing Code:

(1) All welds will be inspected.

(2) Protective wrapping will be holiday tested.

b. Piping shall be subjected to a pneumatic line test at 200 psi for 24 hours.

c. Tests shall be conducted in the presence of a City of Seattle inspector, and a City representative.

4. 02700 -- Storm Detention/Retention System

A. Scope

These standards and procedures apply to the design and installation of storm detention and retention systems.

B. Design Criteria

The City of Seattle's Storm Detention Design Program is based upon the Soils Conservation Services Hydrologic Technical Manuals for Urban Watersheds. The following are the design parameters needed to design the volume of a storm water detention system with the City of Seattle.

1. Area of the site which is impervious (i.e., paved or buildings -- the more landscaped areas will help reduce the overall storm water detention system volume).

2. Area of the site which is pervious (i.e., landscaped -- larger landscaped areas will help reduce the overall storm water detention system volume.)

3. The time of collection, which is the sum of the time of concentration and the overland flow times to the detention pond/tank (the longer the overall time of collection, the smaller the detention volume will be).

The City of Seattle's design methodology is based upon a storm water release rate of 0.2 cfs per acre (100-year storm) and is not based upon the existing storm water runoff from the undeveloped site conditions. Further, the allowable storm water runoff collected from the site and discharged to the City of Seattle's combined sewer system is reduced if there is uncontrolled storm water runoff. Uncontrolled storm water runoff is defined as storm water that, due to the site grading, is not collected on-site and flows off-site to the City of Seattle's combined sewer system within the adjacent streets.

C. Storm Water Collection

1. Site Storage: The entire site storm water is collected and controlled on site with no storm water leaving the site without being routed through the storm water detention system.

2. Substitution storage: If the site grading or existing storm drainage systems are such that some of the site are drains from the site without being routed through the storm detention system, an equal area adjacent to the site can be collected and detained along with the on-site areas to account for the site areas which have been bypassed. This is called substitution storage, which is what was designed at the KeyArena. Note that KeyArena storm detention system was part of the International Fountain project with substitution storage due to the existing grades along with western portion of the site and tee extension storm collection system. This simplified the utility relocation work required for the KeyArena project.

3. Compensatory storage: If a portion of the storm water drainage leaves the site uncontrolled and no substitution storage area is available, the outlet rate of the storm water detention pond is reduced to compensate for this uncontrolled storm water discharge. For example, a representative 12-acre site with just 5% of the area uncontrolled results in the storm water detention volume increasing approximately 45%. The impact of the uncontrolled storm water release is tremendous and should be avoided whenever possible. Note that the City of Seattle does not allow uncontrolled storm water traveling over sidewalks, etc., for safety reasons. If there were other site grading alternatives, they would be required.

It is important to note that the storm water collection system within the site does to contain catch basins as the sole means of collecting the storm water runoff. Overland flows, shallow sheet flows, within the asphalt is acceptable. Additional storm water detention systems could be proposed to mitigate the overall storm detention systems costs such as:

1. Reduce the size of the site that is being developed of phase the project. This could require additional permits for the future work but could mitigate the costs in the interim.
2. Provide storm water detention ponds in lieu of below-grade structures.
3. Optimize the use of precast below-grade storm water detention structures.
4. Provide storm water retention (i.e. infiltration of the storm water into the existing ground). This is dependent upon the existing site conditions.
5. Provide surface ponding within the paved areas.

5. 02730 -- Sanitary Sewers

A. Scope

These standards and procedures apply to the design and installation of sanitary sewer systems.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the following codes, regulations and standards.

1. The Uniform Plumbing Code with City of Seattle Amendments

2. The International Association of Plumbing & Mechanical Officials (IAPMO) Standards

3. City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction

General Requirements

1. Trunk and sub-trunk sanitary sewers will, in general, be routed along pre-established utility corridors. The Redevelopment Project Management Office will furnish the general line routings and sizes, as well as the location of connection points to the existing system.

2. Whenever possible, recorded or estimated water usages projected as required, shall be used to determine the quantity of "used water" to be found in the sanitary sewer connection system. Where such data is not available, loadings shall be based on ultimate growth potentials of 140 persons per acre and per capita usage values of 60 gallons per day and shall be added to the domestic sewage loading. Infiltration and inflow shall be taken at 1500 gallons per acre per day and added to the domestic loading.

3. The consultants will verify that the existing system is adequately sized to accommodate the new line.

Specific Requirements

1. All lateral and trunk sanitary sewers shall be sized to flow full under maximum anticipated flow while maintaining minimum velocities under average flow conditions. In general, design flow velocities shall be kept within the range of 3-8 feet per second.

2. No pipe smaller than 6 inch size shall be used.

3. Manholes shall be located at all changes in grade, alignment or pipe size; with a maximum spacing of 400 feet. Invert elevations of all pipes entering and leaving manholes shall be identified on design drawings.

4. Allowances for hydraulic losses through abrupt change of direction manholes shall be directly proportioned to velocity head.

5. All connections of one sewer line to another shall be made so as to provide a smooth hydraulic gradient, one to the other under full flow conditions, match spring line of the pipes.

6. Laterals shall be sized to carry four times the estimated average flow.

7. Main trunk sewers and sub-trunk collectors shall be sized two and provide times the annual flow.

8. The following items shall be designed in accordance with the listed drawing(s)

   a. Manholes: See Seattle Standard Plan 200.1a.

   b. Safety rung: See Seattle Standard Plan 232.1.

9. Generally, use outside drops at manholes. When connecting to drawing(s) holes, inside drops will be considered if the manhole is at least 54" in diameter and the piping will not affect maintainability. Obtain Project Manager's approval for any inside drops.

C. Products, Materials

   1. PVC pipe shall conform to Section 9-05.12 of the Seattle Standard Specifications with rubber gasket joints. Connections to manholes shall be by an C or GPK manhole adaptor.

   2. Corrugated steel or aluminum pipe is not approved for the City.

   3. Non-reinforced concrete pipe (ASTM C14) may be used only with specific approval of the Project Manager.

   4. Reinforced concrete (ASTM C76) and ductile iron pipes (ANSI A21.51) shall be used under all roads and installations 5'-0" below grade.

5. Ductile iron pipe shall be used under all buildings and extended a minimum of 2' beyond all concrete covered areas next to the building, including raised planter beds.

6. Pipe conveying special wastes shall be of an approved acid resistant material suitable to the use intended. Connect acid waste lines to Acid Waste Manhole per SD-C-34.

7. Transition to other types or sizes of pipe will be made with molded rubber couplings and bushings manufactured by Calder.

8. Pipe and fitting shall be joined by flexible compression rings conforming to ASTM C443

9. Pipe to pipe connections shall be made by gaskets furnished by the manufacturer and installed according to manufacturers' instructions.

10. Portland cement joints are prohibited.

11. Provide clean outs where piping changes direction, at buildings and elsewhere where required to maintain the system. Clean outs shall be full line size per SD-C-38.

D. Execution

   1. Testing

All new lines shall be subjected to testing after installation. In general, such tests shall be exfiltration test or the low pressure air method according to Section 7-17.3(4) of the Seattle Standard Specifications. per APWA and WSDOT 7-17.3(4) A,B,C or 7-17.3(4) D Air pressure test. Tests shall be conducted in the presence of a City of Seattle Inspector, the A/E and the Project Manager.

6. 11640 -- Fume Hood Exhaust Systems

A. Scope

The following are guidelines for designing and specifying fume hood exhaust systems for the City.

B. Requirements

1. Definitions

Access opening. That part of the fume hood through which work is performed: entrance or face opening.

Airfoil. Curved or angular member(s) at the fume hood entrance.

Air volume. Quantity of air, normally expressed in cubic feet per minute (cfm).

Auxiliary air. Supply or supplemental air delivered to a laboratory fume hood to reduce room air consumption.

Baffle. Panel located across the fume hood interior back which controls the pattern of air moving into and through the fume hood.

Biological safety cabinet. A ventilated HEPA filtered enclosure used to handle pathogenic micro-organisms. Provides personnel, environmental, and usually product protection. This enclosure is not a laboratory fume hood.

Blower. Air moving device sometimes called a fan consisting of a motor, impeller, and housing.

Bypass. Compensating opening that maintains a relatively constant volume exhaust through a fume hood regardless of sash position and that functions to limit the maximum face velocity as the sash is lowered.

Capture velocity. The air velocity at the hood face necessary to overcome opposing air currents and to contain contaminated air within the laboratory fume hood.

Counter top. Work surface resting on a base cabinet nominally three feet high.

Duct. Round, square, or rectangular tube used to enclose moving air.

Duct velocity. Speed of air moving in a duct, usually expressed in feet per minute (fpm).

Exhaust collar. Connection between exhaust duct and fume hood through which all exhaust air passes.

Face velocity. Speed of air moving into fume hood entrance or access opening, usually expressed in feet per minute (fpm).

Fume removal system. A combination of the laboratory fume hood and the exhaust system (duct and blower).

NOTE: Room air, makeup air, auxiliary air (if used), and pollution abating devices (if used) are integral parts of a properly functioning system and should be considered when designing a fume removal system.

Glove box. Enclosure used to confine and contain hazardous materials with operator access by means of gloved portals or other limited openings; this enclosure is not a laboratory fume hood.

Imbalance. Condition in which the ratio of quantities of auxiliary air to room air is greater than the design maximum or lower than the design minimum.

Laboratory fume hood. A ventilated enclosed work space intended to capture, contain, and exhaust fumes, vapors, and particulate matter generated inside the enclosure. It consists basically of side, back, and top enclosure panels, a work surface or counter top, an access opening called the face, a sash, and an exhaust plenum equipped with a baffle system for the regulation of airflow distribution.

Laminar Airflow. Airflow in which the entire body of air within a confined area essentially moves with uniform velocity along parallel flow lines.

Laminar Flow Hood. A ventilated HEPA filtered enclosure which normally provides product protection only. Found in horizontal, vertical, vertical exhaust and biological safety models. These enclosures are not laboratory fume hoods.

Liner. Interior lining used for side, back, and top enclosure panels, exhaust plenum, and baffle system of a laboratory fume hood.

Lintel. Portion of laboratory fume hood front located directly above the access opening.

Manometer. Device used to measure air pressure differential, usually calibrated in inches of water.

Makeup air. Air needed to replace the air taken from the room by laboratory fume hood(s) and other air exhausting devices.

Negative air pressure. Air pressure lower than ambient. Negative with respect to: air pressure lower than that in adjacent rooms or areas.

Particulate matter. For this Standard, small, lightweight particles that will be airborne in low velocity air (approximately 50 fpm).

Petes plug. Fitting placed in duct to permit insertion of Pitot tube.

Pitot tube. Device used for measuring air velocity.

Plenum chamber. Chamber used to equalize air flow.

Positive air pressure. Air pressure higher than ambient. Positive with respect to air pressure higher than that in adjacent rooms or areas.

Room air. That portion of the exhaust air taken from the room.

Sash. Movable panel set in fume hood entrance, normally transparent.

Service fitting. Item of laboratory plumbing mounted on or fastened to laboratory furniture or fume hood intended to control the supply of piped gases and liquids for laboratory use.

Slot velocity. Speed of air moving through fume hood baffle openings.

Smoke bomb. Smoke producing device used to allow visual observation of air flow. May include materials such as dry ice in water.

Static pressure. Air pressure in laboratory fume hood or duct, usually expressed in inches of water.

Static pressure loss. Measurement of resistance created when air moves through a duct or hood, usually expressed in inches of water.

Superstructure. That portion of a laboratory fume hood that is supported by the work surface or countertop.

Threshold limit value (TLV). Time-weighted average concentration for a normal eight-hour work day and a forty-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Tip speed. Speed of blower impeller end or tip.

Titanium tetrachloride. Chemical that generates white fumes used in testing laboratory fume hoods. CAUTION: THESE FUMES ARE TOXIC AND CORROSIVE.

Total pressure. Sum of velocity pressure and static pressure.

Transport velocity. Minimum speed of air required to support and carry materials in an air stream.

Velocity pressure. Pressure caused by moving air in a laboratory fume hood or duct, usually expressed in inches of water.

Work area. That part of the fume hood interior where apparatus is set up and fumes are generated. It is normally confined to an area six inches behind the plane of the sash to the face of the baffle, extending from the work surface to a plane parallel with the bottom edge of the sash when the sash is in the full open position.

Work surface. Counter top material area in laboratory fume hood where apparatus rests and where manipulations take place.

2. Fume Hood Terminology

Fume Hood types:

a. Airflow hood - a designation for an airflow fume hood having six (6) inches wide curved vertical facia panels to provide the maximum in streamlined entrance shapes around the hood face to enable air entering the hood to flow in smooth,

uniform, unbroken pattern. This type of hood has a horizontal deflector vane and an automatic air bypass and is the most efficient hood available.

b. Auxiliary-air hood - a designation for an airflow fume hood which operates with 30-70 percent room air and 70-30 percent auxiliary air.

c. Bench hood - a common designation for hoods with working surface approximately 36 inches above floor level.

d. California hood - a common designation for a hood enclosed with glass on all four sides, with horizontal sliding sash on two sides (front and rear). The work surface is usually about 18 inches above the floor level.

e. Closed hood - the designation applied to fume hoods closed on all four sides, with sliding sash at the front of the hood.

f. Conventional hood - the usual designation applied to the older style square front hoods with offset interior ends and without the air bypass feature or curved shapes of any kind. These hoods are generally available in the following types: bench, walk-in, distillation, and perchloric acid.

g. Glove box - a complete enclosure requiring the use of gloves for access to the hood interior, rather than a sliding sash.

h. Walk-in hood - the designation applied to hoods which utilize a concrete floor as a work surface, or in which the built-in work surface rests directly on the floor. This type of hood is useful for bulky materials or large equipment which must be set into the hood. The hoods are available in airflow designs, and usually have a double sash, double hung.

i. Protective coatings - paint films or other materials applied to the interior of fume hoods, blowers, and exhaust ducts to provide corrosion protection. Protective coatings are many and varied, and usually some knowledge of the end use is necessary prior to a suitable factory recommendation.

j. Understructure - furniture cabinet base or leg and apron assembly that supports the fume hood superstructure.

3. Reference

NFPA No. 45 - 1975, Laboratories Using Chemicals

Industrial Ventilation, A Manual of Recommended Practice, A C GIH.

SAMA Std. for Laboratory Fume Hoods, SAMA LF7-1975.

ASHAE Handbook of Fundamentals 1972 edition.

Caplan, Knowlton J. and Gerhard W. Knutson. "Influence of room air supply on laboratory hoods." AIHA JOURNAL. 43:738-746, 1982.

Chamberlin, R.I. and J.B. Leahy. Laboratory Fume Hood Standards, Recommended for the U.S. Environmental Protection Agency. Contract No. 68-01-4661. January 15, 1978.

Keith Carlson, University of Minnesota. Personal Communication, June 21, 1982.

Harry Beaulieu, Boise State University. Personal Communication, June 21, 1983.

Richard Konzen, Texas A&M University, Personal Communication, June 21, 1983.

Thomas K. Wilkinson, National Institute of Health, Personal Communication.

C. Acceptable Types of Fume Hoods

Note: To the extent possible, this standard applies to existing installations.

1. Conditioned air locations: Laboratory hoods should be auxiliary air supplied hoods with a full-length overhead external supply source. The decision for auxiliary air supplied hoods will depend on the availability and final disposition of the conditioned air. No internally supplied hoods should be installed.

2. Balanced air locations: Laboratory hoods shall be bypass type hoods.

3. Special purpose hoods (radioactive, perchloric acid, pathogenic, etc.) shall be individually selected, or designed.

D. Hood Design

1. Face Velocities

a. Hood face velocity requirements for general lab use are listed in the following table.

DESIGN

Face Velocities fpm

Average	Minimum velocity at any location at the face
100 +/- 10%	80

Higher velocities may be achieved by lowering sash

Special Equipment and Uses

gloves boxes slot ventilation perchloric acid carcinogens pathogens radioisotopes	Consult Environmental Health and Safety for applications

See Section H - Chemical Use Factors.

2. Hood Design Characteristics

   a. Each hood shall have a "picture frame" airfoil at the sides, top, and bottom approximately 6 inches wide.

   b. Bottom airfoil shall have an air space between bottom airfoil and the hood bench top. Air space shall be unobstructed by brackets, or configurations which cause turbulence. Airfoils shall allow for inlet of air at bench level when the hood sash is closed. The outside leading edge of an airfoil sill shall be slightly below the hood bench level.

   c. The hood bench shall be dished on all four sides to a depth of approximately one-half inch to contain spills inside hood. This depression (dish) should not be closer than six inches from the front lip of the hood bench top.

   d. The hood interior end panels shall be flush with the entrance shape to prevent eddy currents and turbulence. There shall be no shelves or other obstacles within 18 inches of hood face.

   e. The hood interior back panel shall contain three horizontal slots located at bench level, at the top, and at an intermediate position. The slots shall be able to be adjusted, either individually or in combination, to direct air flow within the hood.

   f. Air velocity in the slots shall be equal to or less than the duct velocity range of 1000 to 1600 fpm and preferably less than 1500 fpm.

   g. Sinks and service fittings shall be located at least six inches beyond the hood face.

   h. A vertical sliding sash shall be provided for hoods unless otherwise specified.

   i. The entry to the fume hood duct should be bell-shaped to provide as smooth a transition as possible.

   j. All materials used in construction of fume hood shall be asbestos free. This includes but is not limited to materials used for interior end and back panels, baffles, the bench, cup sinks, gaskets for access panels and sash, insulation, and the bell-shaped duct entry transition assembly.

3. Specific Hood Design and Performance Requirements for Auxiliary Air Supply Hoods

   a. Must meet face velocity requirements of general lab use hoods.

   b. An auxiliary air plenum may be added to the fume hood. This chamber, when connected to a separate blower and air duct system, shall contain directional vanes and baffles such that the air stream is directed at the hood face and away, as much as possible, from the hood operator

position. The auxiliary air shall be evenly distributed across the hood face at a uniform velocity. The supply velocity shall be such as to direct the supply stream across the full face opening. All of the supply air shall be captured and enter the hood before it is allowed to strike against the airfoil sill and thus be directed into the room. Hoods shall provide efficient fume removal when operating with 50 percent of the exhaust air requirements being auxiliary air and 50 percent room air, when auxiliary air is supplied at temperatures ranging from 70^{o} F to 90^{o} F. The flow of auxiliary air shall be confined to the area immediately in front of the hood, and shall be entrained in the flow of air entering the hood with a capture efficiency of at least 95 percent when operating with the sash up. Auxiliary air hoods shall be provided with a bypass to direct 100 percent of the auxiliary air into the hood when operating with the sash closed. With the sash lowered to three inches from full closed, the bypass shall limit the face velocity to not more than 3 TIMES nor less than 2 TIMES the average face velocity. When the sash is closed, a small amount of room air shall enter the hood under the airfoil sill. The hood sash shall operate smoothly and freely even when operated from one end of the sash and shall hold at any height. Failure to meet the performance requirements shall be cause for rejection of the equipment.

4. Specific Hood Design and Performance Requirements for "Bypass Hoods"

   a. Must meet face velocity requirements of general lab use hoods.

   b. General Design.

      1) An automatic air bypass shall be furnished for hoods with vertical sliding sash at the sash opening. This air bypass shall limit the maximum air velocity through the face of the hood, and provide a relatively constant volume of air through the hood (regardless of sash position) when hood exhaust blower is in operation. The hood air bypass shall not be dependent on mechanical or electrical linkage and shall be completely positive in operation. The air bypass shall be so designed to prevent hot gases, vapors or debris, generated by fire explosion within the hood, from being ejected through it directly at the operator. A design with the air bypass on top of the hood or with horizontal fixed front face louvers directed upward, with louver centerlines not more than one louver width apart is acceptable.

         The airflow fume hood, when properly installed in a laboratory and connected to an exhaust blower of the proper capacity, shall contain and remove fumes generated within the hood. The hood shall operate efficiently at the APPROPRIATE velocity. Hood design shall be such that it will exhaust light or heavy gases efficiently, when the hood is used for ordinary laboratory work in a room free from cross drafts, and without high thermal loads or other special conditions of this nature. Failure to meet the performance requirements shall be cause for rejection of the equipment.

5. Hood Utilities

   a. Controls for hood utilities shall be located outside the hood including any three-pronged receptacles for 110V power.

   b. Hood lighting shall be vapor-proof or explosion proof, depending upon the intended purpose of the hood.

      Light bulbs should preferably, be changed from outside the hood.

   c. Each sink or cup sink in a laboratory hood shall be individually trapped.

   d. Hood electrical switches shall have indicator lights.

   e. Indication lights shall be installed to indicate proper blower operation.

   f. Fume hoods, if factory wired, must be U.L. (or equivalent) listed or wired upon installation by licensed construction electrical contractor.

6. Performance Evaluation

   a. Two Petes plugs shall be installed in the exhaust duct at 90 degrees to each other around the circumference for the purpose of pitot tube insertion.

   b. Performance evaluation shall be done by measuring hood face velocities and by measuring the terminal velocity of supply air. The supply air velocity should be no more than 1/2 to 2/3 of the face velocity.

   c. In addition, smoke tubes or dry ice in water should be used to determine the extent to which the hood contains the contaminant and to check for reverse air flow and turbulence. Alternatively a solution of titanium tetrachloride may be painted on the walls and floor of the hood just inside the sash to provide the same information as obtained by use of the smoke tubes. For new hoods the vendor is responsible for performing the evaluation which is to be approved by the client.

   d. The "OK" for general lab use may be withheld if in the judgment of the investigator, the hood does not meet certain physical requirements, e.g., lack of an air foil picture frame, lack of ventilated storage cabinet beneath the hood working surface, lack of air distribution slots at the rear of the hood.

7. The following manufacturers can meet these hoods design standards with certain models.

   a. Kewaunee Scientific Equipment Corporation.

   b. St. Charles Manufacturing Company

   c. Taylor Division, American Desk Manufacturing Company

d. Hamilton Industries

For currently acceptable models offered by these manufacturers, see Section I - Acceptable Fume Hood Models.

E. Hood Installation

1. General

Laboratory fume exhaust systems must be designed as complete operating units considering chemical use factors, room supply air, room configuration, hood type and location, exhaust fan, and ductwork.

2. Hood location and disturbances

Cross drafts created by the room ventilation system, open windows, operable doors, personnel traffic, etc., can drastically disturb the flow of air entering the fume hood and cause a reverse flow of air out of the front of the fume hood. Room conditions such as these must be avoided by proper selection of ventilation delivery system, permanently locking windows, and locating hoods 10 feet or more away from doors. In no case should the velocity of cross drafts exceed 20 fpm or 20 percent of the hood face velocity adjacent to the hood.

The velocity of supply air shall be no more than 1/2 to 2/3 the face velocity, i.e., 50 to 70 fpm measured at the operator location in front of the hood while the hood is off and the sash open. The velocity of supply air in hoods for which the fan cannot be turned off shall be as above but with the sash closed.

3. Noise

NOISE CRITERIA

SCALE SETTING	AVERAGE DECIBELS
A	62
C	79

Noise measurements to be made at an average distance of one foot from the fume hood with the sash fully open using a type 2 sound level meter per ANSI SI.4-1971 and an octave band filter for 31.5 to 4000 H.

Noise problems may be eliminated by considering several options:

a. Install larger slower-running fans.

b. Insure that fan discharge velocities remain within those indicated in the Table in paragraph F.4.d.

c. Install silencer in duct.

Note: The NC50 curve is approx. equivalent to 59 dBA. The NC55 curve is approx. equivalent to 62 dBA. The NC60 curve is approx. equivalent to 67.5 dBA.

4. Makeup air - general laboratory

   a. Air exhausted through laboratory fume hoods is not to be recirculated.

   b. Positive pressure differentials shall be maintained between rooms to insure a positive air movement from clean to more contaminated areas. Therefore, air supply should exceed air exhausted to office or classroom space and air exhausted should exceed air supplied to laboratory space. Laboratory units in which flammable materials are stored or used must maintain air negative to corridors or adjacent spaces.

   c. Supply may be controlled by automatic dampers that will open and close when the fume exhaust fan is turned from its full volume flow to 50% of full volume flow but at no time is the fan to be completely turned off.

5. Design for growth

   When it is anticipated that hoods may be installed at a future date, minimum provisions should be made by setting aside a good location in the laboratory and adequate space shall be planned for all hood service and utility requirements.

6. Storage

   a. Underhood storage units intended for chemical storage shall minimally contain: recessed flow, metal lining, liquid and gas-tight construction and ventilation flow from outside hood, through storage unit, to hood plenum chamber.

   b. Underhood storage units intended for flammable liquids shall be ventilated and constructed to comply with the requirements of the Uniform Building Code.

F. FAN AND DUCT DESIGN

1. Exhaust Fans

   a. Fans should be weather protected and installed near the building roof. Fan installation in fan room lofts, attics, or rooftop penthouses are preferred. Each fan should be, in any case, the last element of the system so that the ductwork through the building is under negative pressure. All fans should have a receptacle within 25'.

   b. A means of ready access for fan maintenance should be provided.

   c. Fans should be provided with:

      1) outboard bearings
      2) shaft seal
      3) an access door
      4) multiple 150 percent rated belts, or direct drive
      5) fan system shall be chemical resistant throughout and shall have a non-sparking wheel

6) in designing for explosion and fire control, the fan shall be of the non-sparking construction and the V-belt drive shall be conductive.

d. Vibration isolators shall be used to mount fan. Flexible connection sections of ductwork, such as neoprene coated glass fiber cloth, shall be used between the fan and its intake duct when such material is compatible with hood chemical use factors.

e. Each exhaust fan assembly must be individually matched (DFM, SP, BHP, etc.) to each laboratory hood and duct system design.

f. Choice of fan type will be determined as follows:

1) Use straight-radial fans for systems handling moderate to heavy quantities of particulate matter in air.

2) Use backward-cuved fans for systems handling relatively clean (low particulate) air.

3) Axial fans may be used in a vertical mounting for systems requiring washdown as perchloric acid hoods.

g. The transition joint from duct to fan must be of a seamless constant diameter inert corrosion resistant material as approved by owner. The duct alignment must be within one half inch at the hood collar and fan.

2. Utility Cores

a. Adequate space and easy access shall be provided to facilitate inspection, repair, or replacement of exhaust ducts.

b. Utility cores may be central cores that are large enough to be entered; service cores that are accessible through removable panels opening into corridors; or concealed accessible chases located in outside walls.

3. Exhaust Duct Materials and Construction

a. Materials shall be non-combustible, inert to agents to be used, non-absorbent, and free of any organic impregnation.

b. All joints shall be made liquid and gas tight.

c. Smooth, non-porous lining surfaces shall be free of cracks, joints, or ledges.

d. Choice of duct material shall be one based on the compatibility with the materials handled in the hood. Basic characteristics of preferred hood and duct materials are as follows:

1) New installations shall be of 16 gauge (minimum thickness stain-less steel. Stainless steels (subject to attack by acid and

chloride compounds) vary with the chromium and nickel content of the alloy. Type 316L passive stainless with No. 2B finish shall be used for bacteriological, radiological, and perchloric acid hoods.

(Not suitable for hood handling concentrated H C1 and H S0 .) Joint construction for stainless steel shall be "butt" welded (use appropriate filler rod for type of stainless) and ground smooth. If welding is not absolutely possible, an alternate "owner prior approved" corrosion resistant (leak proof) joint may be used subject to passing a pressure test as described in 5) below. For high level radioactive hood exhaust systems where ducts must be dismantleable for decontamination, flanged neoprene gasket joints shall be used.

2) All stainless steel duct must be welded by a "certified " welder.

3) Glazed ceramic ducts and vitrified clay tile ducts are resistant to practically all corrosive agents (except hydrofluoric acid) and should be left in place in currently operating systems. However, if abandoned during remodel projects, they must be designated as "abandoned."

Existing fume hood ducts to be removed during demolition must be steam or hot water cleaned for 24 hours prior to handling and removal.

4) Maximum duct velocities, except for final discharge in 4.c below, shall not exceed those recommended for low velocity systems in the ASHRAE handbook.

5) Newly installed ducts are to be pressure tested such that the duct must hold pressure at two (2) inch water gauge for 24 hours. Owner must observe and approve the test.

4. Exhaust Stacks

a. Exhaust fumes shall be discharged through vertical stacks terminating above the wake cavity of the building or through shorter stacks with sufficient high velocity to project the discharge through the wake cavity into the non-turbulent air passing over the building.

b. Generally, for one or two story buildings, stacks extending at least 30 percent higher than the building height will provide satisfactory dispersal of fume hood exhaust.

c. Discharge shall be directed upward at a velocity of at least 3,000 fpm for stacks extending eight feet or more above the building. For shorter stacks, a vertical discharge velocity of at least 4,000 fpm is required to minimize chances of recirculation.

d. Exhaust stack velocities alluded to in c. above may be attained by restrictions at the top. However, duct and fan-outlet velocities should be as indicated in the following table:

	Recommended	Maximum
Main ducts	1000-1300 fpm	1100-1600 fpm
Fan discharge	1300-2000 fpm	1500-2200 fpm

e. Exhaust stacks should not have weather protection that requires the air to change direction or cause turbulence upon discharge, such as weather caps or louvers.

f. Exhaust stacks which allow for a vertical discharge, yet prevent rain from entering the exhaust system, shall be used.

g. To overcome aesthetic objection, it is important for the design team to plan for the release of contaminants in the concept stage of their design by incorporating an exhaust tower or a cluster of exhaust stacks as an architectural element of the building. Bunching of exhaust stacks has the added advantage of creating a mass of exhaust gases, which is much less readily deflected from upward vertical flow by wind gusts.

G. SPECIAL SYSTEMS

1. General

Hoods and devices handling materials classified as special shall be designed to suit such materials.

2. Perchloric Acid Fume Exhaust Systems

a. Perchloric acid deposits in hoods and ductwork are potentially explosive and, therefore, such systems must be considered to be hazardous.

b. Each perchloric acid hood shall be provided with a separate fume exhaust fan and must be totally independent from any other exhaust.

c. Preferable, perchloric acid hoods shall be located on the top floor to reduce to a minimum the extent of ductwork required.

d. The hoods must be specifically designed as perchloric acid hoods.

e. The ductwork must be welded (TIG process) type 316 stainless steel installed vertically from hood through fan to discharge with minimum (preferably no) elbows. All ductwork shall drain thoroughly.

f. Fans shall be located where a violent reaction will not harm adjacent equipment or personnel. Depending on the location, some type of protective screening may be desirable.

g. Fan casings and hood bottoms must be provided with continuous gravity drainage to the sanitary sewer.

h. The entire system, including duct fans and hood, must be provided with an internal washdown system. The system must be carefully designed and tested to provide as complete a washdown as possible. The interior of the ductwork can be sprayed by various methods which must be reviewed with the Project Manager prior to completion of the design. The washdown system shall be actuated by a manual valve located adjacent to the fume hood.

i. Perchloric acid is not to be used in hoods not specifically designated for this use. (The use of perchloric acid in hoods not designated for this use poses extreme problems for any subsequent hood and duct removal during renovation project.)

3. Special Systems

Each special system must be investigated and a design developed to meet the specific requirements to the approval of the Department of Environmental Health and Safety.

4. Filters

The Property Manager shall be consulted concerning proper filters, air cleaning devices, scrubbers, incinerators, ultraviolet lights, and other devices for special purpose hoods in which radioactive materials, pathogens, or carcinogens are to be used.

H. CHEMICAL USE FACTORS

1. It is emphasized that these listings are merely examples of toxic materials, they are not intended to be all inclusive.

2. Highly Toxic

Gases and vapors of substances with exposure limits below 1 ppm or dusts, fumes and mists of substances with exposure limits below 0.1 mg/M^3.

Examples: (not all inclusive)

l. Gases and Vapors	Dusts, Fumes, and Mists
Acrolein	Asbestos
Hydrazine and derivatives	Silica
Nitrated aromatics	
Metal carbonyls (Fe, NI, etc.)	

Hydrides
Azides
Alkyl mercury and lead compounds
Boranes, Silanes

3. Moderately Toxic

Gases and vapors of substances with exposure limits of 1 ppm and above or dusts, fumes, and mists of substances with exposure limits of 0.1 mg/M^3 and above.
Examples: (not all inclusive)

I. Gases and Vapors	II. Dusts, Fumes, and Mists
Benzene	Acrylamide
Cyanogen, Cyanogen Bromide	Acrylonitrile
Phosgene	Pyridine
Haloforms	Picric Acid
Dimethylformamide	Phenol
Butyl Mercaptan	Inorganic lead compounds
Ketones: MEK,MIBK,MBK	Malathion
Nitric Oxide	Parathion
Formaldehyde	Methyl Methacrylate
Alkanes (C to C)	Nicotine
Aniline	Dioxane
	Gluteraldehyde

4. Low Toxicity

Gases and vapors of substances with exposure limits above 100 ppm or dusts, fumes, and mists of substances with exposure limits above 15 mg/M^3.

Examples: (not all inclusive)

I. Gases and Vapors	II. Dusts, Fumes, and Mists
Freons	Corundum, Alundum
Alkanes (C_7 to C_n)	Emery
Ethanol	Fiberglass
Acetone	Limestone
Ethyl Ether	Mineral Wood Fiber
Methanol	Paper fiber
	Plaster of Paris

I. ACCEPTABLE FOR HOOD MODELS

1. Bypass Type Fume Hoods

Manufacturer	Models
Kewaunee Scientific Equipment	Airflow Supreme and Hoodair

St. Charles Manufacturing Co.	Aerostream Bench Vertical Company Sash Hood
Taylor Division, American Desk Manufacturing Co.	Type 200 (with fixed vanes)
Hamilton Industries	Safeair

7. 15050 -- Basic Materials and Methods

A. Scope

These standards and procedures apply to the selection and installation of pipe, pipe fittings, valves, and piping accessories for domestic hot and cold water, heating water, cooling water, steam and condensate, sanitary and storm drains, rainwater leaders, compressed air, vacuum, and most gases. Special piping requirements, including fittings, valves, and accessories, will be identified in the related section.

B. Design Criteria

Codes, Regulations, and Standards

All products, materials, equipment, and installation work shall conform to the following codes, regulations, and standards of latest issue:

1. American Standards Association
2. Uniform Building Code
3. Uniform Mechanical Code
4. Uniform Plumbing Code
5. Underwriters Laboratories Standards
6. Factory Mutual Standards
7. Washington State Energy Code
8. Seattle Fire Code
9. American Water Works Association

C. Products, Materials and Equipment

1. Pipe and Fittings

a) All pipe and fittings shall conform to the appropriate ASA standard.

b) Thermometers shall be industrial quality, glycerin type, insertion pattern, including wells when located in piping. Scale length shall be 9 inches. Scale range shall be 30 to 240 degrees Fahrenheit in hot water piping, or 0 to 100 degrees Fahrenheit in central cooling water or chilled water piping.

c) Gages shall be 4 inch minimum size with a scale range approximately twice the operating pressure. Units of measure shall be shown on the face plate.

2. Valves

a) Valves shall be of domestic manufacture (Hammond, Stockam, Kennedy, or Victualic) and conform to the appropriate ASA standards.

b) Valves and packing materials shall be specifically designed for the service intended.

c) Valves shall be flanged or threaded; may be solder pattern for 2 inch and smaller copper piping.

d) Valves shall be rising stem type with union bonnet or other type if the application dictates.

e) Relief valves shall be rated in accordance with the ASME code.

f) Plug valves larger than 2 inch size shall be lubricated type.

g) Balancing valves shall be plug type.

3. Strainers

a) Strainers in 2 inch and smaller piping shall be wye type.

b) Strainers in larger than 2 inch piping shall be basket type, except steam piping.

c) Strainers in steam piping shall be wye type.

d) Strainer screens shall have a free area not less than three times the free area of the pipe line. Perforations shall be 1/16 inch size.

1) Screens in steam strainers shall be stainless steel.

2) Screens in other strainers shall be brass.

e) Strainers shall be of domestic manufacture.

4. Sleeves

a) Sleeves shall be either galvanized schedule 40 pipe or galvanized sheetmetal.

b) Sleeves shall be galvanized pipe where exposed to view, where flooding may occur, or where penetrating floors on grade or exterior walls below grade.

5. Hangers

a) Hangers for exposed piping shall be rods with pipe rings; 3/8 inch minimum rod size.

b) Concrete inserts shall be used in new construction; shall be cast, not stamped, metal.

c) Expansion shells may be used in existing construction; shall not be used in new construction.

d) Powder actuated inserts shall not be used.

6. Motors

a) Motors and motor controls shall be in accordance the requirements noted in Volume 4, Electrical.

b) Motors that are installed in equipment exposed to the weather shall be totally enclosed type, even though a weatherproof cover is provided.

7. Vibration, Acoustic Treatment and Seismic Bracing

a) Equipment vibration must be compensated for during the design stages. Mountings and connections shall be carefully arranged.

b) Rotating equipment on grade shall have spring type or rubber-in-shear vibration isolators.

c) Rotating equipment in areas not on grade shall have spring type vibration isolators and inertia bases.

d) Inertia bases shall be equal in weight to all equipment located thereon. The vibration isolators shall support the equipment, including the inertia base.

e) Springs shall be large diameter, stable type which do not require guides or snubbers.

f) Mechanical rooms shall have acoustic treatment on walls and ceiling if adjacent areas will be affected by noises generated in the mechanical room.

g) Seismic restraint provisions shall be carefully included so as to meet the intent of the Uniform Building Code and the Uniform Mechanical Code and any other local codes having jurisdiction with more stringent requirements; and not diminish vibration isolation provisions.

D. Execution

1. Pipe and Fittings

a) Threaded connections shall be tapered V-threads per ASA standards.

b) Piping shall be carefully arranged to allow ample movement and flexibility for expansion and contraction due to temperature changes.

c) Piping shall not be installed below slabs on grade; except for waste and vent piping.

d) Branch connections, particularly in heating systems, shall have not less than two 90 degree changes in direction, with reasonable pipe lengths to allow for pipe movement.

e) Expansion loops are preferred to manufactured expansion joints or flexible connections.

f) Horizontal distribution from vertical mains shall, generally, occur in the ceiling of the floor served and down-feed to the devices.

g) Provide unions, or flanged connections, and isolation valves at equipment so equipment may be conveniently removed for repair.

h) Provide electrically insulating dielectric couplings at connections between copper pipe and zinc (galvanized) coated pipe.

i) Joints in black steel piping larger than 2 inch size shall be welded, threaded or flanged.

j) Welding outlets (thread-o-lets) may be used only where branch piping is smaller than the main; otherwise, welding tees shall be used.

k) Welding shall be performed by welders certified by the National Certified Pipe Welding Bureau.

l) Thermometers shall be shown on the drawings at all locations where a fluid mixing or heat transfer occurs and located so they may be read from the floor.

m) Gages shall be shown on the drawings and located on all services entering the building, at pressure reducing valve outlets, pump inlets and outlets, etc. Gages shall be mounted on 1/2 inch size pipe extensions with 1/2 or 1/4 inch shut-off valves.

2. Valves

a) Valves shall be provided to permit isolation of portions of the building piping systems for maintenance, alterations and repair work without shutting down entire systems.

b) Valves shall be installed to isolate all equipment for repairs.

c) Valves shall be installed with the stem vertical, preferably; not less than horizontal under any circumstance.

d) Where multiple services distribute from a pipe shaft, stagger the valves so they may be conveniently reached; all valves must be completely accessible.

e) Valves shall be installed with adequate room to permit removal of the bonnet, disk and trim without removing the valve from the line.

f) Globe valves shall be provided where throttling is required; except for balancing valves.

g) Valve tags shall be provided for each valve where the destination is not visible from the valve; shall state service and destination.

3. Strainers

   a) Wye strainers shall be equipped with a gate valve.

   b) Strainers shall be provided ahead of automatic control valves, traps, and in main service piping to buildings. Traps provided for a device having an automatic control valve will not require strainers.

   c) Strainers sized up to 1 1/2" shall be made of brass or bronze; portable water system strainers 2" or larger shall be double-coated with electrostatically applied heat fused epoxy on interior and exterior.

4. Sleeves

   a) Provide sleeves for all piping penetrations through concrete and masonry.

   b) Sleeves shall extend 2 inches above all finished concrete floors and sealed with "Link Seal" or equal.

   c) Sleeves for insulated piping shall be sized to allow the insulation to pass through.

   d) Sleeves through exterior walls below grade shall be sealed with Link Seal or approved equal.

   e) Sleeves through floors and firewalls shall be firestopped with U.L. Listed firestopping material.

5. Hangers

   a) Pipe rings shall be sized to encircle the insulation when a vapor barrier is required; shall have protective shields as indicated in the insulation section.

   b) Pipe rings may penetrate the insulation when a vapor barrier is not required.

6. Headers

   a) Every service entering a building shall include a service header.

   b) Provide a shut-off valve in the service piping immediately upon entry into the building.

   c) All meters, strainers, pressure reducing valves, back-flow preventers, major branch distribution connections, etc., shall occur at the header.

   d) When incoming domestic water service exceeds 80 PSI, provide a pressure reducing station with two PRV's in parallel, each valved to operate independently.

   e) The header shall be arranged so that bypass connections will ensure service to the building when maintenance is required on various components.

   f) Components shall be spaced apart with two pipe diameters between flanges.

g) Header assemblies shall be located generally four feet above the floor.

h) Header assembly with backflow protective devices shall not be installed higher than five feet (5') from centerline of uppermost devices. Any bypass lines installed for servicing of backflow device shall have a like-kind device installed in line.

7. Pressure Reducing Valves

Pressure reducing valves sized 1-1/2" shall be Watts Series US or USB; sizes 2" or larger shall be Watts Series 1150.

E. Piping Pressure Testing

1. General

a) The pressure testing requirements defined herein apply to all piping systems.

b) Testing shall be performed by the Contractor on all piping after erection; before insulation covers the joints being tested. Furnish all necessary equipment and material and make all taps in the pipe, as required. The Owner's designee will witness the tests.

c) The following piping and equipment shall not be subjected to pressure testing:

1) Rotating machinery, such as pumps, turbines, and compressors.

2) Pressure-relieving devices, such as rupture discs and pressure safety relief valves, when the relief pressure is within ten percent of the test pressure.

3) All vessels, regardless of rating, when using gas pressure for testing.

4) Pressure gauges where the test pressure exceeds their scale range.

5) In-line instrumentation.

2. Test Procedures:

a) Two pressure gauges shall be installed for each testing system; installed as close as possible to the low point of the piping system.

b) Calibration records for gauges used for testing shall be submitted to Owner's witness.

c) All vents and other connections that can serve as vents shall be open during filling so that all air is vented prior to applying test pressure to a system.

d) If the maximum operating conditions of piping attached to a vessel are the same as those of the vessel, the piping and the vessel may be tested together. If the vessel has different maximum operating conditions, it must be isolated and tested separately.

e) Examination for leakage shall be made at all joints and connections. The piping system shall show no visual evidence of weeping or leaking. Any visible leakage shall be corrected at the Contractor's expense.

f) If the pressure falls after the pressurizing source is shut off, the source of pressure loss must be determined and corrected. The system must be able to hold the test pressure for the test duration specified without any detectable loss.

g) If the ambient air temperature is less than 40 degrees Fahrenheit (F) at the time of pressure testing, the test medium must be heated as required to achieve the following temperatures when filling is complete:

1) 70 degrees F minimum for pipe wall thickness one inch or less.

2) 100 degrees F minimum for pipe wall thickness greater than one inch.

h) Piping designed for vapor or gas which is specified to be hydrostatically tested shall be provided with additional temporary supports, if necessary, to support the weight of the test liquid.

3. Special Requirements for Gaseous Pipe Testing:

a) The Contractor shall recognize the hazards associated with compressible fluid testing and shall take all necessary precautions to protect all personnel. All piping to be tested shall be secured to prevent damage to adjacent piping and equipment in the event of a joint failure. Any instruments or devices that could be damaged by the test shall be removed from the piping or suitably isolated prior to applying the test. Prior to starting the test, the Contractor shall notify the Consultant and Owner.

b) A preliminary pneumatic test not to exceed 25 psig shall be applied to the piping system prior to final leak testing as a means of locating major leaks. Examination for leakage, detected by soap bubbles, shall be made at all joints and connections. After all visible leaks have been corrected, the pressure in the system shall gradually be increased to not more than one-half of the test pressure, after which the pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no evidence of leakage. Any visible leakage shall be corrected at the Contractor's expense.

4. Testing Media Requirements:

a) Clean, fresh city water shall be used for hydrostatic testing. Such water shall be protected with an approved

b) Oil-free clean dry air shall be used for gaseous testing.

c) After hydrostatic testing, all water shall be drained immediately. Care shall be taken not to pull a vacuum during draining - open all vents.

5. Test Repairs:

   a) Materials such as gaskets, bolting, etc., damaged during tests and flushing shall be replaced.

   b) New gaskets shall be used each time a flanged joint is made up.

   c) Any welded joint that is defective shall be repaired in accordance with the applicable requirements. Repaired components shall be reexamined by the original method to determine freedom from defects, and all repaired joints shall be retested. Costs for such repair shall be the responsibility of the Contractor.

6. Test Records: Records shall be made by the Contractor for each piping installation. These records shall include, at a minimum, the following items:

   a) Date of test.

   b) Description and identification of piping tested, size(s).

   c) Test fluid and initial and final temperatures.

   d) Test pressure.

   e) Test duration.

   f) Remarks, to include such items as: leaks (type, location); repairs made on leaks.

   g) Signature and date of person witnessing the test.

   h) Certification by Contractor and reviewed by the Owner.

F. Equipment Performance Testing

1. Each piece of equipment for which performance capacities are identified in relation to various pressures and pressure differentials, or temperatures and temperature differentials shall be installed and tested in-place to verify that the required capacity can be achieved. Each final performance verification test shall be performed in the presence of the Owner's representative.

G. Cleaning of Piping Systems

1. Following assembly and testing, piping systems not specifically listed a "not to be wetted" shall be flushed with water to remove any debris and other foreign material. Flushing velocities shall be a minimum of 2.5 feet per second. Cone strainers shall be inserted in the connections to attached equipment and left there until cleaning has been accomplished to the satisfaction of the Owner's representative.

2. Lines designated as requiring drying shall be dried immediately after the completion of the flushing. Before forced drying is started, control valves and in-line instruments which may be damaged are to be removed and replaced as necessary with pipe spools. Instrument air (minus 40 degree Fahrenheit dew point) or nitrogen is to be used to purge the piping

until a minus 20 degree Fahrenheit dew point is reached. Each low point drain and the end of each branch line shall be blown until the minus 20 degree Fahrenheit dew point is reached. After each section of piping is dried and approved by Owner, the in-line instruments are to be replaced.

8. 15160 -- Pumps

A. Scope

These standards and procedures apply to the selection and installation of pumps for hot water circulation, sump and steam condensate return systems. Not included are vacuum pumps, heat pumps, sewage lift stations, ejectors, air pumps, or piston pumps. Related sections include Fire Protection (15300) Plumbing (15400) and Central Cooling Water Systems (15535).

B. Design Criteria

Codes, Regulations and Standards

1. All work shall conform to the following codes, regulations and standards of latest issue:

2. The Uniform Plumbing Code with City of Seattle Amendments

3. Underwriters Laboratories Standards

4. NFPA 20 Standards

Design Review and Submittals

1. Design submittals of related systems shall include pump data showing impeller diameter and complete pump curves through full operating range.

General Requirements

1. Pump selection shall be based on the highest efficiency nonproprietary products available.

2. Piping system design shall be based on ensuring lowest brake-horsepower per unit flow rate at maximum flow and head.

3. Pumps shall be located where easily accessible for service, yet isolated to prevent pumping or vibration source noise from disturbing the occupied area.

4. If possible, select pumps so that one size larger impeller may be installed, to provide flexibility for future requirements.

5. Discharge head information for pumps shall be calculated by the A/E.

6. Stand-by pumps shall be provided only where a short duration shut-down for repairs and maintenance cannot be tolerated.

Specific Requirements

1. Pumps shall not operate at more than 1800 rpm.

2. Centrifugal type pumps should be selected so that shut-off head is not more than 25% greater than operating head.

3. The pump head shall be calculated and included in system design computations.

4. Where the pump inlet is above water supply level, both suction and total head shall be included in design computations.

5. Motors for pumps shall be sized so they will not be overloaded at any point on the operating curve.

6. Pump casings for Central Cooling Water (CCW) service shall have pressure ratings as follows:

   125 psi class when located at 150 foot elevation or above. (Refer to Seattle Datum.)

   250 psi class when located below 150 foot elevation.

7. "In-the-line" circulators shall only be used for extremely small capacity requirements. If used, they shall be located where they may be conveniently maintained. Isolation gate valves should be on each side of the pump.

C. Products, Materials, and Equipment

1. The pump shall be a complete, integrated unit consisting of pump, motor, shaft, frame, and base; as manufactured at the factory.

2. Pumps shall be centrifugal, end suction type with vertically split casing.

3. Close coupled pumps shall be used for most applications unless the capacity and service justifies a frame-mounted type.

4. Chilled water pumps shall be frame-mounted, not close coupled, so that the entire casing and connections may be completely insulated.

5. Mechanical seals or packing glands shall be provided on all pumps.

6. Mechanical seals for hot water heating pumps shall be certified by the pump manufacturer to be suitable for the maximum expected water temperature and chemical treatment used.

7. Hot water pumps not designed for exposure to water containing ferrous oxides must be equipped with bypass connections to keep seals flushed.

8. Pump casings should have tappings for gauges which shall be equipped with pipe extensions and shut-off valves for gauge installations.

9. Large pumps should have an air cock in the casing.

10. Sump-type condensate pumps shall be vertical shaft type with the motor located above the sump; submersible pumps shall not be used.

11. Sump and condensate pumps shall be in duplex or simplex arrangement.

12. Condensate pumps should be floor mounted, cast iron type, and guaranteed for 210° F. water without flashing.

13. Hot well type condensate pumps shall have a cast iron or concrete sump.

D. Execution

1. Locate pumps in mechanical spaces with easy access whenever possible.

2. Floor mounted pumps shall be on concrete bases, four (4) inches minimum height, and grouted to the base.

3. Provide guards over shafts and couplings in accordance with WISHA/OSHA requirements.

4. Pumps shall be accessible for service and maintenance: with a minimum of 18 inches on two adjacent sides.

5. Each pump shall be isolated with full size gate valves and unions or flanges for easy removal for service, and hose fitted drain valves.

6. Pumps without gauge tappings shall be otherwise fitted with inlet and outlet gauges and shut-off cocks.

7. Provide balancing valve in the pump discharge piping so the design flow rate may be set.

8. Provide check valves in the pump discharge piping when pumps are operating in parallel, standby, or whenever a reverse flow may occur.

9. Controls for condensate pumps shall provide for "lead-lag" start and shall automatically alternate the pumps on the "lead" start.

10. Provide all pumps with inlet strainers as part of the piping or pump inlet accessories.

11. Flexible connections are not acceptable. Arrange the piping for flexibility without a need for flexible connections.

12. Submit as-built drawings of systems with pump installations shown and maintenance/service manuals at job close out.

9. 15190 -- Mechanical Identification

A. Scope

These standards and procedures apply to the tagged and painted identification of piping, duct work, and equipment.

B. Design Criteria

1. All piping, ductwork, and equipment shall be color coded as follows: (The manufacturer and listing are only for the purposes of identifying appropriate paint colors.)

Service Color	Cowman Campbell	Comparable to
Steam Aluminum	#1201	
Condensate	Orange	#333
Hot Water Heating	Buff	#514
Central Cooling Water	White	#300
Cold Water	Dark Blue	#324
Cold Water-Non Potable	Light Blue	#561
Hot Water - Potable	Bright Yellow	#339
Hot Water-Non Potable	Dark Yellow	#341
Gas	Green	#331
Air	Black	#321
Fire Service	Red	#342
Waste, Soil Vent, Rain Leader	Brown	#329
Duct work (including insulated)	Grey	#337
Equipment & Fans	Grey	#337
Other Services	Grey	#337

2. Piping and ducts shall have the name of the service and direction of flow either painted or tagged in place. Steam lines (with pressure greater than 10 psi), gas and air lines will also indicate pressure and temperature.

3. Each major piece of equipment or system shall have its name and I.D.# (as specified in contract drawings) either painted or tagged in place.

4. Each valve shall be tagged to indicate the service, and equipment, I.D.# and temperature of the line controlled.

C. Products

1. Color coding will consist of semi-gloss enamel finish coat.

2. Equipment nameplates shall be laminated black plastic with lettering cut through to white background. Plastic strips with raised letters made by a marking device are not acceptable.

3. Valve tags shall be sized 1" x 2-1/2" and constructed of 0.030 inch thick brass inscribed with lettering 5/16 inch high. Laminated plastic tags, constructed similarly to nameplates, will also be acceptable.

D. Execution

1. Color coding will occur under three conditions where equipment and lines are in mechanical areas, finished areas, and concealed.

a. In mechanical spaces and other maintenance areas, surfaces will be painted.

The following methods shall be used to paint equipment and systems.

(1) All surfaces to be painted shall have at least one primer coat and one finish coat.

(2) Insulated surfaces shall be coated with an appropriate primer-sealer before applying the finish coat.

(3) Zinc coated surfaces shall be properly primed before applying the finish coat.

(4) Factory finished surfaces shall not be repainted unless the original finish has been damaged.

(5) Stainless steel and chrome plated surfaces shall not be painted.

b. In finished areas, color banding rather than painting shall be employed with two (2) inch bands appearing every 20 feet and/or at least once in each space. Colored tape shall generally be used, except when unavailable, banding may be painted on.

c. Where piping and ductwork are concealed, they should be color banded minimally at each provided access point, where the line penetrates a wall or floor, and every 15 feet along horizontal and vertical lines.

2. One example of taped banding should be located in the vicinity of painted surfaces to indicate the corresponding relationship.

3. Information appearing on each major piece of equipment or system shall typically be painted in black, two (2) inch, block style lettering.

4. Nameplates shall be used for equipment too small for two (2) inch lettering.

10. 15250 -- Insulation

A. Scope

These standards and procedures apply to the insulation of piping, ductwork and associated mechanical equipment, and liquid storage vessels.

B. Design Criteria

Codes, Regulations, and Standards

All work shall conform to the following codes, regulations, and standards of latest issue:

1. Factory Mutual Standards
2. Seattle Energy Code
3. Seattle Fire Code
4. Seattle Mechanical Code
5. Seattle Plumbing Code
6. Underwriters Laboratories Standards
7. Washington State Energy Code.

General Requirements

1. All surfaces which can be insulated when it is desirable to reduce energy loss or gain, avoid undesired condensation, and reduce corrosion shall be insulated.
2. Insulation of ducts shall conform to the requirements of the Seattle Energy Code.
3. Minimum pipe insulation requirements shall be as required by the current Seattle Energy Code or the current Washington State Energy Code, whichever is more restrictive.

Specific Requirements

1. A vapor barrier jacket is required for chilled water piping, equipment, refrigerant suction piping, domestic cold water piping, rainleader piping, air handling ducts and equipment with air temperatures of 55^{o}F. or less.
2. Pipe insulation in utility tunnels, up to the building service header main valve, shall have a uniformly ribbed, 0.01 inch minimum thickness metallic casing with a vapor barrier lining.
3. Fittings, valves, and flanges shall have an insulation thickness no less than the adjacent piping but must be removable without damage for easy reapplication.
4. Demolition (removal) of carcinogenic insulation containing asbestos shall follow procedures outlined in the Asbestos Abatement chapters of OSHA/WISHA.

5. Pipe insulation in maintenance areas (mechanical rooms, accessible shafts, etc.) is subject to mechanical damage (crushing, abrasion and laceration) resulting from maintenance activities. Rigid insulation materials protected with appropriate casings and vapor barrier linings are required in these spaces.

6. Oversize Pipe Rings, Inserts, and Shields: Install the pipe insulation and jacket extending through the pipe hanger ring. Provide an extra high density insulation insert and metal shield within each hanger, except where pipe covering protection saddles are welded to the pipe.

   a. Insulating Inserts: Extra high density insulating inserts shall be the same thickness as pipe insulation, and shall be Pittsburgh-Corning "Foamglas" or Pipe Shields "Thermal Hanger Shield" and shall cover not less than the lower 40 percent of the circumference of the insulation; sizes of section, 6 inches minimum length up to 6 inch outside diameter, 8 inches minimum length for larger sizes. "Foamglas" shall not be used for high pressure steam. Install the insulating insert section to replace a cutout section of insulating material within the insulation jacket, with tightly fitted butt type joints. For pipe on trapeze channel hangers, provide Pipe Shield Model A3000 insulated pipe support which covers 100 percent of the circumference of the pipe.

   b. Metal Shields: Except where pipe covering protection saddles are specified, provide outside of the jacket and inside of each hanger, a metal shield of 18 gage sheetmetal, minimum, covering lower 40 percent of the circumference of the insulation, length not less than that specified for cut-in section of high density insulating insert. On 6 inch and larger pipe, shields shall be 14 gage minimum, two pipe diameters in length.

C. Products

All insulation, facings, coatings, adhesives and other accessories shall have a fire hazard rating not to exceed 25 for Flame Spread and 50 for Fuel Contributed and Smoke Developed; ratings determined by UL Standard No. 723, NFPA Standard No. 255, test results from the approved testing laboratory shall be available to indicate that fire hazard ratings for materials do not exceed the above amounts.

D. Execution

Insulation shall have a durable finish suitable for painting for color coding, or other identification marking.

11. 15300 -- Fire Protection

REFER TO APPENDIX B -- FIRE PROTECTION SYSTEMS

12. 15400 -- Plumbing Systems

A. Scope

These standards and procedures apply to the design and installation of potable water systems.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the latest issue of the Uniform Plumbing Code or the Seattle Plumbing Code, whichever is more stringent.

Design Review and Submittals

1. Information required at each design phase is listed in the A/E Agreement. Any deviations from that list must be approved by the project manager. The final construction documents must include all details to allow the contractor to complete the systems without needing additional information.

2. The contract documents must include complete riser diagrams showing all fixtures, valves, recirculation lines, pipe sizing, etc. A detail of each water header is also required.

3. Submittal information shall include catalog cuts of all fixtures, valves, fittings, pipe, hangers, solder, etc.

Specific Requirements

1. The City is served by the City of Seattle pressure system with a reservoir elevation of three hundred sixteen (316) feet.

2. When incoming water pressure exceeds eighty (80) psig, provide a pressure reducing station with two PRV's (each sized at 2/3 of total flow) in parallel, each valved to operate independently. A minimum pressure of twenty five (25) psig should be provided at the highest point of the building. The assembly shall include appropriate valves, strainers, gauges, drains, etc. and include a bypass.

3. Each building service shall include a water meter. Each building tenant unrelated to city departments (e.g. retail business tenant) will be submetered for water use. It is also recommended to submeter any large single uses of water within a building or facility.

4. The building non-potable water headers shall have reduced pressure back flow preventers.

5. Non-potable water provided by double check valves shall be limited to low hazard fire-sprinkler and irrigation systems. Irrigation and fire system backflow preventers shall be located inside the building mechanical room rather than outside. High hazard irrigation and fire systems shall have reduced pressure principal backflow devices (RPBD) or (RPDA for fire. Drains off those devices shall be connected indirectly to a receptor capable of handling the full flow of drain as desired.

6. The plumbing system should be divided into smaller systems with isolation valves separating them. This will allow a section of the building to be worked on without affecting the remainder of the building.

7. Systems shall have hot water storage tanks and use low pressure central plant steam whenever possible. The unit should be sized for seven (7) psig steam. Electric hot water heaters or booster heaters will be used during central plant shut-down plans.

8. Provide booster heaters for dishwashers and other equipment requiring higher hot water temperatures. Do not raise the temperature of the building system.

9. The potable hot water system should be designed to heat water to 125^{O}F.

10. Provide dielectric unions whenever dissimilar piping materials are used.

11. Provide shock absorber type water hammer arresters in lieu of pipe air chambers. Each shock absorber shall be provided with an isolation valve to allow for its removal without affecting the rest of the building. Each shock arrestor and its isolation valve shall have an access panel.

12. Provide access doors for all plumbing system components that require maintenance. The access doors should be located on both the architectural and mechanical plans and coordinated.

13. Seismic bracing must be provided and coordinated with the structural engineer.

14. Water piping shall not be installed below slabs on grade except for trap priming lines.

C. Materials

1. The building water header shall be constructed type L copper pipe.

2. All building distribution piping shall be type L copper tubing.

3. Fittings on copper tubing shall be wrought copper or cast brass, solder pattern. All connectors 2-1/2" in diameter shall be Victaulic or equivalent.

4. Solder shall be 95-5 tin antimony or approved equal. No lead type solders shall be allowed on the job site.

5. Plumbing fixture partition stop connections, through the wall, shall be brass pipe.

6. Dielectric unions shall be used between copper and zinc coated materials.

7. Preferred manufacturers are as follows:

Product	**Manufacturer**
toilets	American Standard (AFWALL
flush valves	Sloan Royal
shower valves	Powers Hydrogaurd
lavatory faucets	Delta 520 – WFMPU
kitchen sink faucets	Delta 400 WF

mop sink faucets	Chicago 305 VBR
back flow protection	Febco Brand

D. Execution

1. Provide access doors for all plumbing system components that require maintenance.
2. All piping shall be installed on the warm side of the insulation for freeze protection. No pipe shall be installed in an area that could experience below freezing temperatures.
3. All piping shall be sloped to allow the system to be drained. A drain valve should be provided at the low point of the system along with a drain to take the water away.
4. All water piping should be insulated and painted as outlined in Section 15190 Mechanical Identification.

13. 15411 -- Waste and Drains

A. Scope

These standards and procedures apply to the design and installation of waste and drain lines inside and within five (5) feet of the building envelope only. All sanitary and storm drain systems beyond five (5) feet of the building lines shall be covered under Sections 02720 Storm Sewers and 02730 Sanitary Sewers.

B. Design Criteria

Codes, Regulations and Standards

1. All work shall conform to the latest issue of the Uniform Plumbing Code or Seattle Plumbing Code, whichever is more stringent.

Design Review and Submittals

1. Schematic drawings shall include fixture locations.

2. Include riser diagrams in drawings.

3. Show invert elevations of all sanitary drain lines leaving the building on drawings.

4. Indicate acceptable slope of piping both inside and outside.

Specific Requirements

1. The minimum size of side sewers shall be six (6) inches.

2. All waste drains shall be gravity systems. Sump pumps and sewage pumps shall not be used without specific approval.

C. Materials

1. Waste piping and drainage systems under slabs on grade shall be extra heavy cast iron soil pipe.

2. Roof drains shall be cast iron or brass, with cast iron or brass high dome strainers. The first section of pipe below the drain must be cast iron or brass.

3. No PVC, CPVC, ABS or galvanized piping shall be used within the building envelope.

D. Execution

1. All pipes, valves, clean-outs, and particularly waste piping, must be accessible for maintenance. Those recessed in wall cavities must have access doors, removable panels, or other approved methods for access.

2. Food preparation and service areas require extensive piping. Access is extremely important. Such areas shall not be located on a slab on grade. Where located above a suspended ceiling, the ceiling must be 100% accessible.

3. Wastes and clean water drains shall be collected independently in each building and carried separately to the city sanitary sewer and storm drains respectively. If no storm drain exists within 200 feet of the building, connect clean water drains to sanitary sewers and provide for future connection to storm drains.

4. All footings shall have footing drains connected to the storm drain system. Footing drains shall not be connected to an interior sump pump.

5. All area drains, yard drains, window well drains, and the like shall be connected to the storm drain system.

6. Invert elevations of sanitary sewer lines leaving the buildings shall be of sufficient depth to permit future connection of a waste line from any point in the basement area.

7. Drains from transformer vaults having oil-filled transformers and shop areas where oil is present shall connect to sanitary sewers through a City of Seattle approved oil interceptor.

8. Crosses shall not be used in waste piping.

9. Connections in waste piping for food service areas shall turn down with a 1/8 bend at the connection to the next branch.

10. Waste piping from garbage disposals shall be carried separately to a major waste pipe, with as few bends as possible and completely accessible clean outs.

11. Floor drains shall be connected to the sanitary sewer. Drains for fire sprinkler system shall be six (6) inches minimum and shall be connected to storm drains.

12. Mechanical rooms, pipe trenches, tunnels and other areas with piping shall be equipped with floor drains. Provide primed floor drains.

13. Avoid installing drain lines in complicated architectural work; if installed, use brass pipe with bronze fittings.

14. Provide trap primers for floor drains and funnel drains in mechanical rooms; and other places where traps may dry out. (Use timer type).

15. Waste and drainage piping crossing excavated areas shall be supported on precast concrete beams supported by the building structure and undisturbed earth.

16. Clean outs shall be the full size of the piping served.

17. Drainage from flammable or hazardous chemical/liquid storage rooms must not be connected to the sewer systems. Coordinate a special drainage system with the Fire Marshal.

18. P-traps for all fixtures other than lavatories and similar usage sinks shall have integral clean outs. Drum traps shall not be used.

19. Pipe bedding under floor slabs shall be Type IV.

14. 15500 -- Heating Ventilation and Air Conditioning

A. Scope

These standards and procedures apply to the design and installation of steam and hot water heating systems, air moving and cleaning systems, and cooling, humidifying, and dehumidifying systems to appropriately interface with existing resources/ systems.

Electric heat may be used as a supplement for a heat pump. Radiant heating is acceptable. Mechanical constant volume mixing boxes are to be avoided and shall not be used without review.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the following codes, regulations and standards of latest issue:

1. Seattle Energy Code
2. Seattle Building Code
3. Seattle-King County Refrigeration Code
4. SMACNA
5. ASHRAE Standards
6. National Fire Protection Association Standards
7. ARI
8. U/L
9. NAFM

Design Review and Submittal

1. Schematic drawings shall identify all systems, and include single line flow diagrams and energy balances. Special occupancy zones shall be called out and systems identified.
2. A review during design development should include single line duct layouts, equipment layout and fresh air intake calculations, and an outline of specifications.

General Requirements

1. Central heating, ventilating, and air conditioning systems are preferred with equipment located in basement and penthouse mechanical rooms.
2. Roof-mounted equipment shall be avoided if possible. If required, equipment shall have weatherproof enclosures and screening.

3. Careful consideration should be given to air intake and exhaust discharge requirements and locations.

Specific Criteria

1. Heating

   a. Heating shall be by circulating hot water where appropriate to building.

   b. Radiation shall be sized for 100% of transmission losses.

   c. Hot water converter selection shall include a 0.001 water side fouling factor.

   d. Hot water systems shall be two pipe design with reverse return and down-feed.

   e. Hot water systems shall be zoned according to building orientation with flow water temperature reset by outdoor temperature.

   f. Steam coils should be used only for preheat utilizing a two position valve. Use low pressure steam no greater than 15 psig.

   g. Select finned pipe radiation to extend for entire length of each glass area.

2. Ventilation

   a. All building spaces suitable for present or future occupancy shall be served by mechanical ventilation.

   b. All supply air systems shall be designed for 100% outdoor air intake capability to be available for cooling during moderate weather, but design shall also allow for recirculation when exhaust air quality is suitable.

   c. Fan rooms shall not be used as supply or exhaust air plenums.

   d. High velocity system design shall not be provided for systems less than 20,000 cfm (ref. Chart C-9, ASHRAE 1981 Fundamentals).

   e. Provide perfecters in all fan systems over 5000 cfm.

   f. Air intakes shall be a minimum of eight (8) feet above grade; air exhaust discharges shall be at the highest point of the building, if possible.

   g. Ventilation shall be provided through centrally ducted systems, or individual ventilating assemblies such as fan coil units or unit ventilators.

3. Air Conditioning

a. Use cooling water design temperature rise of 10-12°F where appropriate to building.

   b. Independent cooling shall be used for applications requiring year-round control of temperature.

c. Air cooled condensers or cooling towers shall be used in lieu of City water cooled condensers.

4. Specific Interface Requirements

a. Steam service brought into buildings at 75 psig shall terminate in a steam header, then be distributed through a pressure reducing station.

b. Cooling water is available from the central plant system on a seasonal basis; flow is obtained by a pressurized differential between supply and return mains, with temperatures adjusted by outdoor conditions. Details are explained in Section 15535 CENTRAL COOLING WATER SYSTEM.

c. Provide bypass relief valves across isolating valves in branch lines from CCW flow and return.

C. Products, Materials and Equipment

1. Heating Materials

a. Steam piping shall be Schedule 40, black steel with screwed cast iron or welded steel fittings, main branches 1-1/2" minimum.

b. Condensate piping shall be Schedule 80, black steel.

c. Hot water piping shall be Type L copper with branch piping more than 25 lineal feet long to be 3/4" minimum. Schedule 40 black steel pipe may be used for 6" or larger in Mechanical Rooms.

d. Joining of 6” or larger pipe and fittings shall be Victaulic couplings and fittings or approved equal.

2. Ventilation Materials

See Section 15880 AIR DISTRIBUTION

3. Air Conditioning Materials

Chilled water piping shall be the same as for hot water.

4. Heating Equipment

a. Steam coils shall be non-freeze type with perforated inner distribution tubes with vertical tubes; each section individually trapped.

b. Traps at end of high pressure mains shall be inverted bucket type. Traps for low pressure mains shall be float and thermostatic or thermodynamic type.

c. Hot water converter steam control valves shall electronic. Siemans is the standard manufacturer.

d. Hot water heating systems shall be closed type.

e. Air vents shall be automatic with a cast iron or non-ferrous body, copper ball float and needle or ball type air valve.

f. Hand valves for radiators or convectors should be packed type suitable for servicing.

g. Surface mounted convectors shall have sloping top. Avoid custom enclosures.

h. Converters shall be ASME approved, stamped and State Boiler Inspector's certificate forwarded to central plant. Use low pressure steam only (15 psig maximum); capacity based on 7 psig steam.

5. Ventilation Equipment

a. Preferred fan design is single inlet, single width centrifugal type with backwardly inclined air foil blades, however, utilization of airfoils, propellers, and duct axial flow fans is encouraged where appropriate.

b. Fan volume control shall be provided when the system has features to cause a variance in volume.

c. Provide rigid structural steel base for both fan and motor with slide rails for drive adjustment. Inertia bases are required for fans not on grade floors. Hinged motor bases are acceptable.

d. Filters shall be selected as follows:

See Appendix D, Air Filters.

Specific applications (absolute, grease)

e. Filters shall have an 85% efficiency (dust spot method using atmospheric dust) at 500 feet per minute face velocity.

6. Air Conditioning Equipment

a. Maximum fin density for coils shall be 10 fins per inch.

b. Use of sprayed coil dehumidifiers is to be avoided, but if used, units shall be standard cataloged and rated, not field fabricated.

c. Air vents shall be automatic with a cast iron or non-ferrous body, copper ball float and needle or ball type air valve.

d. Independent chilled water system shall have an open type expansion tank fitted with automatic fill, overflow, and gauge glass.

e. Independent water chillers shall have controls that prevent the chiller from operating unless chilled water pump, condenser water pump, condenser fan, etc. are operating.

f. Install bypass relief valves across isolating shut-off valves in branch piping for the CCW flow and return main.

D. EXECUTION

Maintenance

1. Heating

a. Sectionalize down fed hot water piping systems with isolating and drain valves to simplify servicing without draining large volumes of water during routing maintenance and repair.

b. Provide a condensate meter for each building.

c. Hot water converter location shall allow for tube removal.

d. All major system components, including filters, shall have reasonable access for servicing.

e. Steam headers shall have valved branches to each specific load, hot water, storage heater, converter, heating coil, etc.

f. Pressure reducing stations shall include at least two valves sized for 1/3 - 2/3 of total load. Show loads on drawing.

g. High pressure steam (75 psig) condensate shall be flashed in a flash tank to the low pressure steam system.

h. All pressure steam supply main branches over 12 feet long shall be dripped.

i. Do not provide strainers ahead of traps, drains, coils, converters, or other heat exchangers, but provide adequate static head above traps.

j. Do not attempt to lift condensate by steam pressure.

k. Do not install steam or hot water piping below slabs on grade.

l. Cast iron radiation, finned radiation, and air heating coils shall not be installed on the same pumped circuit.

m. Locate valves for hot water coils or other major heating components so that each unit and its control valve can be serviced without draining an entire system or riser.

n. Provide a hose end drain valve on each hot water coil.

o. Provide gate valves at all air vents.

p. Locate expansion tanks at the highest point possible, and fit with gauge glass, drain, vent, and shut-off valve.

q. Convectors and radiation shall be valve controlled, dampers will not be accepted.

r. All steam control valves shall be arranged to be normally closed.

2. Ventilation

a. Fan Bearings shall be ball type (selected for extended life) lubricated with grease fittings extended through fan casing for easy access, sealed ball bearing type permanently lubricated or sleeve type oil lubricated.

b. Provide each fan drive with an easily removable guard assembly protecting drive and shaft, with access for tachometer use.

c. Each air filter shall have a dedicated adjustable inclined manometer installed to indicate filter pressure drop.

d. Locate all air heating and cooling coils so that water jet or steam cleaning may be employed. Provide ductwork access panels on each side.

3. Air Conditioning

a. Provide a balancing valve in the return piping from each individual cooling coil.

b. Provide gate valves at the inlet and outlet of each cooling coil, or other major component. Locate valves so that each cooling unit, and its control valve, can be serviced without draining an entire system or riser.

c. Provide access panels in ceilings or partitions for servicing concealed valves or vents.

d. Provide a Btu meter in the building system served from the CCW System. Meter shall have a Btu computer, temperature differential indicator, and 6 digit Btu and gallon registers. Btu register shall read in "Hundred Thousands."

e. Chilled water piping shall have pressure gauges and thermometers at evaporator inlet and outlet.

f. Provide a flow measuring device such as "Barco" or "Rinco" venturis in the coil piping of each supply fan.

15. 15650 -- Refrigeration

A. Scope

These standards and procedures apply to the design and installation of field fabricated refrigerating systems for air conditioning systems, and heat pumps.

B. Design Criteria

Codes, Regulations, and Standards

All work shall conform to the following codes, regulations and standards of latest issue:

1. Seattle Mechanical Code
2. ASHRAE Standards
3. Seattle-King County Refrigeration Code
4. Seattle Energy Code

16. 15845 -- Energy Recovery

A. Scope

These requirements and recommendations apply to the incorporation of energy recovery into all building and system designs for new construction and remodel projects.

B. Design Criteria

Codes, Regulations, and Standards

1. Energy recovery systems are, for the most part, extensions of building heating, ventilating, and air conditioning systems. As such, codes, regulations, and standards shall apply as required in conformance with those sections of this document.

Design Review and Submittal

1. During the schematic design phase, the consultant shall investigate ways and systems to accomplish heat reclamation and make recommendations as to which system(s) shall be used. The presentation will include the estimated cost and payback period.

2. The preliminary design submittal shall include the selected energy recovery systems with estimated cost and payback period. Details will include operation sequence, diagrams of systems and equipment lists.

General Requirements

1. Each scheme shall include calculations of all energy saved and all energy required to operate the system (parasitic energy). For these evaluations contact the Project Manager for current energy cost.

   Energy cost to operate heat pumps shall be based on electrical costs and manufacturers' published data.

D. Execution

1. All work shall be completed in accordance with the appropriate sections of the FDS Manual. Once complete, the system shall be tested and balanced as outlined in Section 15990 (Testing, Adjusting and Balancing). The consultant should review the report with the Project Manager to make sure that the system is operating properly.

17. 15880 -- Air Distribution

A. Scope

These standards and procedures apply to the design and installation of air distribution and ventilation systems, materials, and equipment. These shall include air terminal units involving heat transfer and forced air supply.

B. Design Criteria

Codes, Regulations and Standards

Work shall conform to the following codes and standards of latest issue:

1. Duct construction details shall conform to the recommendations of the ASHRAE guide and data book and SMACNA.

2. Rectangular, round, and oval ductwork sheet metal gauges and construction shall conform to the appropriate tables in the ASHRAE guide and SMACNA.

3. Fire dampers shall be provided in accordance with the Uniform Building Code and the National Fire Codes.

Design Review and Submittals

1. Drawings shall show the specific location of fire dampers.

Specific Requirements

1. Supply outlets shall be suitably located to avoid drafts caused by colliding air patterns or disruption of air flow caused by vertical obstructions in the ceiling such as drop light fixtures, ceiling beams, or proximity to the wall.

2. Rectangular ductwork shall not be used in high velocity air systems.

3. High velocity ductwork leakage shall not exceed eight (8) cfm per 100 square feet of duct surface under a pressure of five (5) inches wg.

4. Balancing dampers shall be provided in each duct to a single outlet or inlet and be located adjacent to the connection to the main branch.

5. Quadrants (easily accessible) shall be provided for each balancing damper for adjusting and locking. Balancing dampers above hard ceilings shall have rod extension with quadrant in ceiling.

6. Balancing orifice type dampers behind grills (such as opposed blade dampers) shall not be used without approval of The Project Manager.

7. Air foil turning vanes shall be provided in square elbows.

8. Turning vanes should be used in return air or exhaust ductwork.

9. Plenums shall sit on concrete curbs four (4) inches minimum and will be held in place by angle iron bolted to the curb with rubber or neoprene gasket.

10. Each plenum area shall be provided with a light. All lights in a single fan system shall be switched as a group. Switch shall include an "ON" pilot light.

C. Products

1. Perforated plate ceiling diffusers should not be used without approval from The Project Manager.

2. Light troffer diffusers with return air incorporated in the light fixture are preferable.

3. Air deflection must be adjustable for all types of ceiling supply diffusers.

4. If light troffers are used, the light fixture must be compatible with the troffer selected.

5. Exhaust ductwork from high humidity areas such as shower rooms shall be aluminum sheet metal with welded and flanged watertight joints.

6. Nonmetal ductwork should not be used without the approval of The Project Manager, except flex ductwork is acceptable as connecting duct to diffusers but shall not exceed two (2) feet in length.

7. Plenums shall be rigidly constructed of eighteen (18) gauge (minimum) galvanized sheet metal.

8. Angle iron bracing inside plenums shall be galvanized.

9. Flexible connections at fan inlets and discharges in general shall be made with fire resistant neoprene impregnated fiberglass cloth.

D. Execution

1. Access doors to ducts (hinged, latched, with sponge plastic seals) shall be provided upstream and downstream from all coils and elsewhere where frequent access is required.

2. Access doors shall be provided for all plenum areas with latches operative from both inside and outside the plenum.

3. All access doors shall be self-closing due to the direction of air flow and by pressure differential.

4. Access panels shall be provided at all fire dampers and elsewhere where occasional access is required. These access panels may be held in place with sheet metal screws with sponge plastic seal for sizes less than 12" x 12". For large size access panel use hinges and/or latches.

18. 15900 -- Environmental Control Systems

DIRECTIONS FOR USE OF GUIDE SPECIFICATION

A. The Guide Specification (Appendix A) names a certain manufacturer and vendor. We have selected the provider based on the product and acceptable local performance. We have made a substantial effort to determine that this provider can meet specifications. There shall be no exceptions to the approved vendor.

B. Appendix A is a guide specification that shall be modified to the extent necessary to meet the needs of the particular project, however, the final specification shall not deviate from the basic concepts and requirements set forth. Make an exact copy of the guide specification and then modify it to meet the particular project needs and numbering system. Do not try to blend it with your own standard specification or that of a vendor. If you require vendor support, you must utilize the approved vendor. Your primary input will be the Sequence of Operation, Points Matrix and indication of point locations on the drawings. We are constantly upgrading our guide specification and will indicate important changes through the review process. We will occasionally make an official update and send it to all holders of the FDI manual. We encourage direct communication.

C. Here are some fundamental concepts for your design process:

1. The standard for HVAC control systems includes a PC Based, but not PC host dependent, Local Area Network DDC System with a highly distributed architecture. Electric/Electronic actuators and sensors shall be utilized. For new construction pneumatic actuators are only to be used in specifically accepted, limited applications. Pneumatic systems are only acceptable for small additions to existing pneumatic systems.

2. The DDC system shall provide freeze protection as a backup to local dedicated thermostats which must be shown on drawings and called out in specifications.

3. At the time of bid, the City would like to have a parts price list guaranteed for the duration of the contract.

4. Any large fans with inlet vanes must be specified with electric actuators of high quality and installed by the fan manufacturer. We would prefer a variable frequency/torque starter controlled fan.

5. Mechanical drawings and specifications shall call out valve CV and pressure requirements, anticipated close off pressure differential, line size, damper size, and indicated actuator function (including: 2 Position, Modulating, Spring Return, Normally Open, Normally Closed, Etc.).

6. In general the City wishes to use rotating valves so that the same actuator may be used for both dampers and valves. When space and pressures permit, use ball or shoe valves instead of lift and lay valves. We would prefer to reduce a 4" line down to 2" in order to use a ball valve rather than use a 4" lift and lay valve with a lower CV. Butterfly valves are not acceptable for modulation use if the required CV is less than that of the largest ESBE valve (CV=491). Butterfly valves with the plate riveted or bolted to the stem are not acceptable. Use DEMCO, Vicatulic or approved equal.

7. The control architecture specified requires that all inputs and outputs occur at the smallest, most highly distributed level of stand alone control equipment. The intention is that no single failure will impact a large segment of equipment. These I/O devices shall provide for dry contact, resistive, 0-10 VDC and 4-20 ma. inputs. Outputs shall include 0-10 VDC.

8. Provide points matrix showing all input/output requirements.

9. Provide sequence of operation for all controlled equipment.

10. If thermometers and gauges are part of this package then ensure that they are well described for good quality and readability from the floor; per requirements indicated elsewhere in Volume 3.

19. 15990 -- Testing, Adjusting, Balancing

The following guidelines are used by the City for soliciting bids from TAB firms on specific projects. These guidelines are provided as reference materials and are to be included in the Contract Documents. These guidelines will be provided to Contractors upon request.

To provide for the necessary coordination assistance between the Contractor and the TAB firm, include Appendix E, Testing, Adjusting, and Balancing, in the contract documents. The appendix should be edited to accommodate the specifics of the project. Consult with the Project regarding specific items.

A. Scope

These standards and procedures apply to the testing, adjusting and balancing of all equipment and components to assure the optimum performance of mechanical systems.

Quality Assurance Qualifications

1. Balancing and testing of the Heating, Ventilation and Air Conditioning (HVAC) Systems will be performed by a qualified firm specializing in HVAC systems testing, adjusting, and balancing and noise level measurement. Systems shall be tested after installation and as part of commissioning.

2. Qualifications Requirements:

   a. Certified member of the Associated Air Balance Council (A.A.B.C.) or National Environmental Balancing Bureau (N.E.B.B.).

   b. Submit a current list of projects, including references and phone numbers, and name of principal technician.

All work shall proceed under the general direction of City Project Management which shall provide coordination between the Contractor, A/E, and Central Plant.

B. Design Criteria

Codes, Regulations and Standards

All work shall conform to the following Codes, Regulations, and Standards of latest issue.

1. Associated Air Balance Council (AABC), "National Standards for Field Management and Instrumentation Total System Balance," Volume One, No. 81266.

2. ASHRAE Handbook, 1987 HVAC Systems and Applications, Chapter 57.

3. AMCA Publication 203 Fan Application Manual, Part 3, Field Performance Measurement.

4. National Institute of Health (NIH)

5. Industrial Ventilation Guide, American Conference of Governmental Industrial Hygienist.

6. National Environmental Balancing Bureau (NEBB)

Design Review and Submittals

1. The Testing, Adjusting, and Balancing (TAB) firm shall prepare and submit, prior to any balancing work, a work schedule following but not limited to the one outlined in Execution.

2. All requirements for design review meetings and submittals shall be adhered to according to the Schedule of Work.

C. Balancing Reports

1. Report Submittals

   a. First submittal: Two (2) copies of rough draft report, to include narratives that describes (a) all problem areas that may require major construction or design changes and (b) the building control systems to demonstrate comprehension of the job system operation.

   b. Intermediate submittals: Three (3) copies of complete report for approval by theProject Manager and the Consultant A/E for Record.

   c. Final submittal: Three (3) copies of the approved report.

      1) Bind each copy of the manual as single volumes in 3 ring binders. Imprint bound edge of volumes with the name of the building and the words "Testing, Adjusting, and Balancing Report". Imprint front of the volume with the name of the building, project name, project number, Owner, General Contractor, Mechanical Subcontractor, Architect, Mechanical, Engineer, and the TAB firm.

2. The report shall include a narrative and the data necessary to describe the system(s), operating equipment, and how they function. Identify equipment using the construction drawing identifiers. Provide ventilation and heating hot water piping riser diagrams if either one is not already a part of the construction drawings. Include the following data:

   a. Fans:

      1) Installation data:
         a) Manufacturer and model
         b) Size and type
         c) Arrangement, discharge, class
         d) Motor HP, voltage, hertz, frame, and full load amps
         e) Identification data

      2) Design data:
         a) Total cfm (for exhaust hoods fan flow must agree with hood design requirement)
         b) Static pressure (total)
         c) Motor HP, rpm and amp
         d) Fan rpm
         e) System or service

3) Fan recorded/measured data:
   a) Cfm
   b) Static pressure
   c) Rpm
   d) Motor operating amp, volts
   e) Motor operating bhp (calculated)
   f) Drive sizes (sheaves, belts & shaft)
   g) Fan curve cfm based on fan data
   h) Date of readings

b. Duct Systems:

1) Duct cfm - mains:
   a) Duct size (s)
   b) Number of pressure readings
   c) Tabulation of velocity measurements
   d) Average velocity
   e) Duct measured cfm (each)
   f) Duct design cfm

c. Individual air terminals:

1) Supply, return, or exhaust terminal identification (room number, name location and number designation)

2) Manufacturer's catalog identification and type

3) Application factors (velocity, effective area, flow direction), etc.

4) Design and recorded velocities - fpm

5) Design and recorded quantities - cfm

d. Controllable air devices/boxes:

1) Identification (room or suite number and name)

2) Manufacturer's catalog identification and type

3) Applicable controller

4) Effective flow area

5) Maximum measured velocity or flow and static pressure

6) Minimum measured velocity or flow and static pressure

e. Fume Hoods:

1) Identification (room or suite number and name and number designation) and location

2) Manufacturer's name, model, or size, and type (i.e., fume, perchloric, walk-in, canopy, or bio-safety)

3) Inlet face area of hood with sash at maximum height (with sash stop released)

4) Design is inlet flow at 100 fpm through inlet face

f. Pumps:

1) Installation data:
   a) Manufacturer and model
   b) Size
   c) Type drive
   d) Motor HP, voltage, phase and full load amp
   e) Identification data

2) Design data:

   a) Gpm
   b) Head
   c) Rpm
   d) Bhp and amp

3) Recorded data:

   a) Discharge pressure (full-flow and no-flow)
   b) Suction pressure (full-flow and no-flow)
   c) Gpm from pump curve
   d) Operating head
   e) Operating gpm (from pump curves if no meter)
   f) No-load amps (where possible)
   g) Full-flow amp
   h) No-flow amp
   i) Calculated Bhp
   j) Seal water flow, gpm

g. Heat reclaim unit:

1) Design data and recorded data

   a) Manufacture, model, and type
   b) Size
   c) Design flows, temperatures, and efficiencies
   d) Air pressure drop across unit supply and exhaust
   e) Entering and leaving temperatures
   f) Calculated CFM through sections
   g) Calculated heat gain or rejection and efficiency

h. Fan coil/Unit heater:

1) Design data and recorded data:

   a) Mbh

b) Gpm
c) Entering and leaving water temperature
d) Entering and leaving supply air temperature
e) Supply air cfm
f) Exhaust air cfm
g) Water pressure drop
h) Identification data
i) Motor, hp, frame, rpm, amps, phases, and volts
j) Fan rpm, bhp, amps
k) System static pressure, in H2O

i. Fan Drives and Pump Impellers

1) Provide final drive size information and necessary pump impeller changes for each fan or pump.

a) Driven pulley pitch diameter, bushing and shaft size.
b) Belt size and quantity.
c) Drive pulley pitch diameter, bushing and shaft size.
d) Impeller diameter and type.

D. Execution

1. Schedule of Work

All preparations and execution of work shall proceed according to the following schedule to include, but not be limited to, the following items:

a. Provide a complete set of work sheets to specify each piece of equipment and show each terminal device.

b. Make a "first pass" through the entire system (approximately one month prior to beginning any work) to determine the critical path and to locate possible construction or design problems.

c. Following this inspection, the TAB firm shall:

1) Immediately submit a report, if necessary, to the Project Manager of any construction or design deficiencies that could delay or affect balancing.

2) Meet with The Project Manager to discuss the results and determine the scope of work to be completed by the Contractor and/or A/E.

d. Project Management will meet with Contractor and A/E to determine schedule to complete work and resolve problems.

e. A/E ensures that work is properly and sufficiently completed to the extent that testing, adjusting. and balancing shall continue uninterrupted to completion.

f. Meet with A/E to determine scope of work to be completed in "second pass."

g. Make additional pass through system and complete the majority of the balancing. The area should be ready for complete occupancy at the end of this phase of the work.

h. Provide three (3) copies of the rough draft of the report to the Project Manager, and the Consultant A/E. This should include the narrative that describes all problem areas that may require major construction or design changes.

i. Meet with Project Manager and Consultant A/E to discuss the report and determine the scope of work to complete the work.

j. Complete the field work so that the system is completely balanced and mark all dampers to show the final settings.

k. Complete the report and submit three (3) copies to the Project Manager and Consultant A/E for review.

l. Meet with Project Managerand Consultant A/E for final review comments.

m. Complete the report and provide three (3) bound copies to Project Manager.

n. Final acceptance of the general construction contract shall occur when all testing, adjusting, and balancing work is completed.

2. Testing Equipment

Instrumentation shall be provided by Contractor as necessary and appropriate to perform the work. The type and number of instruments utilized shall be determined by the type of systems involved and the number of personnel required to complete the work by the time stipulated. The instruments shall be recently factory calibrated and shall be used with the factory-determined application factors. This instrumentation shall include, as appropriate, but not be limited to the following, or approved equal:

a. Ammeter, clamp-on type, Amprobe

b. Anemometer, 4" Biram type

c. Anemotherm, Anemostat Model 60

d. Pitot tube and air velocity meter, Dwyer Model 400

e. Pyrometer, contact type Alnor Type 4200

f. Speed indicator, J.B. Biddle "Jagabi"

g. Static pressure gauges, Dwyer "Magnehelic", 0 to 4" wg; 0-10" w.g.

h. Velometer, Alnor Type 3002

i. Terminal (cfm) flow measuring hood

3. General Testing, Adjustment, and Balancing Procedures

a. Care shall be exercised while performing the work so as to avoid damaging the work of other trades, particularly paint and ceilings. Where damage is inevitable to gain access to the various devices, the Contractor shall be notified so that appropriate corrections can be made and proper accessibility provided. Damage incurred by the TAB firm shall be it's responsibility to correct.

b. Records shall be maintained at all times which shall readily indicate all steps, adjustments, and intermediate and final readings. The records shall indicate on each trial whether a damper or balancing device was cut or opened. The records shall be maintained on reproduceable type forms which shall include measurement locations, design capacities, appropriate manufacturers' performance factors, and dates and names of personnel involved.

c. Final settings shall be clearly marked on each balancing valve, quadrant, etc.

d. Frequently work will have to be performed in areas that are partially or fully occupied, which may require the work to be accomplished during other than normal working hours. Such occupancy shall not be considered justification for any deviation for the requirements outlined herein or any extra payments. Where overtime work is required for expeditious completion of the balancing work, payment of premium rates for such work shall not be allowed without specific approval of the Project Manager in writing, in advance.

e. System operation will be by the City Engineers to suit the requirements of the balancing work. System filters shall be new at start of testing, adjustment, and balancing work.

f. Resourcefulness is frequently required in order to properly balance some of the more complex and intricate systems. This may dictate the use of methods and techniques not herein before stated. Where "standard" balancing procedures cannot, due to physical conditions or other circumstances be employed, alternate methods shall be determined and approved by Project Managerand Consultant A/E.

4. Air System Procedures

a. Measure and adjust all ventilation openings on all systems to produce the air flow rates shown on the contract drawings. Air flow rates, as adjusted, shall be within a tolerance of plus or minus 5% from the design rates shown on the contract drawings. Where this is not possible or reasonable the reasons should be clearly documented in the final report. In addition to physical problems, energy consumption and noise reduction should be considered in recommending possible deviations.

b. When complete, at least one air path from each fan, or each high pressure mixing box, to an air outlet or inlet shall have all volume dampers wide open. This path shall be clearly identified. This is to ensure minimum static pressure buildup in the system as a result of balancing.

c. Determine the minimum operating static pressure required to deliver the required air volumes, for each inlet vane controlled fan or other automatic static pressure regulator, and note the setting adjacent to the regulator and on the record sheets.

d. The total air volume handled by each system shall be measured, and recorded, by readings taken at appropriate locations in the fan intake or discharge plenums. These measurements shall be compared with the design system volumetric rate and the individual inlet or outlet readings to correlate and substantiate the system measurements.

e. Determine drive ratio changes required in order to obtain the optimum operating fan speeds, review in detail with the Consultant A/E and the Project Manager, and recommend such changes in writing. Fan speed changes shall not be made without the approval of the Project Manager.

f. After final drive ratio changes have been completed, make a final set of readings, and adjustments if necessary to ensure the system balance. Record the final fan rpm, pulley sheave and belt sizes, and motor amperage.

5. Water System Procedures

a. Measure and adjust all radiation, coils, heat exchangers, etc., that constitute a part of the heating and/or cooling system, to produce the capacities shown on the contract drawings.

b. Flow rates may be determined by temperature differentials between the entering and leaving water conditions or by total energy transfer calculations involving air volumes, entering and leaving air temperatures, and entering and leaving water temperatures.

c. All measurements shall be made with the design air flow rates air entering temperatures, and flow water temperatures existing during the balancing process. If this is not possible, review with the Project Manager and Consultant A/E and agree on an alternate scheme, in writing.

d. Capacities, as adjusted, shall be within a tolerance of plus or minus 5% from the design ratings shown on the contract drawings or, when leaving water temperatures are used to indicate a balanced condition, within a tolerance of plus or minus 1^{o}F.

e. When complete, at least one path from the pump discharge to the pump intake, except for the balancing valve used to set the pump operating head, shall have all balancing valves wide open. This is to ensure minimum friction drop in the system as a result of balancing.

f. Using appropriately located flow meters or pressure gauges and the pump manufacturer's pump curves, set the operating pressure differential across the pumps to develop the correct flow rates.

End of Section 3